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THE SUPERIORITY OF FINE CATGUT OVER FINE SILK AS A MUCOSAL SUTURE IN GASTRIC SURGERY

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WHILE investigating the tissue reaction of various suture materials in abdominal surgery performed on animals, we were impressed by an outstanding and constant feature: the sloughing of silk through the gastric mucosa when this material was used in surgery of the stomach. This was indicated by the presence of long, redundant, intraluminal loops of silk with areas of necrosis at their points of entrance and exit, as well as between them. Further, the presence of these loops has been noted gastroscopically by Schindler, as well as by us, in humans after gastric surgery in which silk was used as the suture material. In all instances when fine catgut was used, there was a minimal mucosal reaction and at no time were loose strands noted in the gastric lumen.

SUTURE MATERIALS

The argument concerning the use of catgut or silk for ligatures and wound closure has continued since 1869 when Lister noted a localized collection of cloudy fluid about a silk ligature which had been used for ligation of an aneurysm 10 months before. Kocher (7, 8) and Halsted, in the early days of aseptic surgery, and Howes (4), Howes, Sooy and Harvey (6), Whipple, Elkins, in recent years, have championed the cause of silk.

Halsted stated:

> "Let the surgeon interested in making the comparison, take a running subcuticular stitch on the one side with catgut, on the other side with fine silk (No. A or AA) and observe the healing wounds from day to day. There is not only greater local reaction in the cases sewed with catgut, but in them the wounds will occasionally open at one or more points to discharge a few drops of clear or cloudy fluid."

It is noteworthy that Halsted did not mention the size of catgut. At that time (1913), Nos. 1, 2, and 3 catgut were the sizes most generally used; and, in 1914, Phillips speaks of No. 00 as the smallest size. In fact, No. 000 catgut which corresponds in size to No. A silk was not available until several years later. The present fine gauge catgut, including No. 0000 and No. 00000 which have diameters closely approximating that of No. AA silk, was placed on the market only in recent years. Therefore, Halsted's comparison was not a fair one, because in his time he did not have available sizes of catgut sutures as fine as the sizes of silk which he was using. It seems obvious that Halsted's superior results with fine silk as compared with those which he obtained with catgut were due to the fact that he used much smaller sizes of silk which, in

From the Foundation for Clinical and Surgical Research and from the Department of Surgery and Laboratories of the Philadelphia General Hospital.

themselves, tended to provoke less of a foreign body reaction. Further, the use of larger needles with larger sutures produces greater trauma and dead space which add to the insult to the tissues and invoke heavier leucocytic response.

We have repeatedly observed that tissue reaction to catgut is proportional to the size of the suture. When fine catgut is used, there is less tissue trauma from the suture itself and from its transit. Apposition is more nearly perfect since more stitches may be placed in a given space, lessening the possibility of dead space. These observations have been reported by Bower, Burns, and Mengle.

EXPERIMENTAL INVESTIGATIONS

In order to evaluate our observations concerning the behavior of catgut and silk as mucosal sutures, the following experiments were carried out:

Operation. A vertical bisection of the stomach of each of 14 dogs was made and the continuity of the organ re-established by using two rows of continuous sutures. The same operating team used the identical technique on each dog. All animals had been on the same diet for 1 week and each weighed approximately 12 kilograms. Under morphine and atropine sedation and open drop ether, aseptic technique being used, an upper left rectus incision was made. Bisection was always made on a line drawn from the anastomosis of the left and right gastric arteries on the lesser curvature to the anastomosis of the left and right gastroepiploic arteries on the greater curvature. The lesser peritoneal cavity was entered by ligating the gastroepiploic vessels approximately 1 centimeter to either side of the elective site. The stomach was then gently pulled down, and ligation was performed on the gastric arteries of the lesser curvature, 1 centimeter to either side of the proposed bisection site. In this manner a minimal and constant diversion of blood flow was induced. The stomach was divided between two straight rubber clamps with fine straight scissors. The bisection was closed with two layers of continuous, running sutures of catgut or silk in the posterior and anterior walls. The first suture line included the serosa and muscularis, while the second included the mucosa and submucosa. Then the clamps were removed and the abdomen was closed in layers with continuous linen sutures. Animals were operated on in pairs: chromic catgut was used for the stomach sutures in one and black silk in the other of each pair.

Suture material. In order to eliminate the size of the suture as a possible factor in causing tissue reaction, we decided to employ identical sizes of absorbable and nonabsorbable suture materials. We selected No. 0000 black silk which gauged 0.006 inch in diameter because this size corresponds to No. AA silk as used by Halsted. For the absorbable suture, we chose medium chromic catgut having an average diameter of 0.006 inch which thus was the equivalent in bulk of the silk. This suture material is designated No. 00000 catgut.

The No. 00000 chromic catgut was more easily handled. It has more body than silk and does not cling to gloves or tissues. However, the No. 0000 silk presented no real difficulty. Neither suture broke at any time during the experiments.

Postoperative care. The postoperative management was the same in all cases: small amounts of water on the second day, milk on the third day, milk and bread the fourth day, and unrestricted diet on the fifth day. All animals recovered and all wounds healed by primary intention.

Pathological specimens. Stomach specimens of each series were taken at 2, 3, 4, 5, 7, 10, and 14 day intervals. Colored photographs of the mucosal suture lines were made in each instance within an hour. Histological sections were made of each specimen.

Gross appearance. Two days: Both specimens show the same amount of traumatic petechial hemorrhage along the suture line, due to the use of forceps and the needle transit. The No. 00000 catgut line is cleaner (Fig. 1). The No. 0000 silk shows two necrotic areas; one 0.5 centimeter and one 0.8 centimeter in length in the lower half of the specimen. In 6 areas, beginning redundancy of the silk loops is present, due to sloughing through the mucosa (Fig. 2).

Three days: No. 00000 presents a very clean wound with almost complete (at least

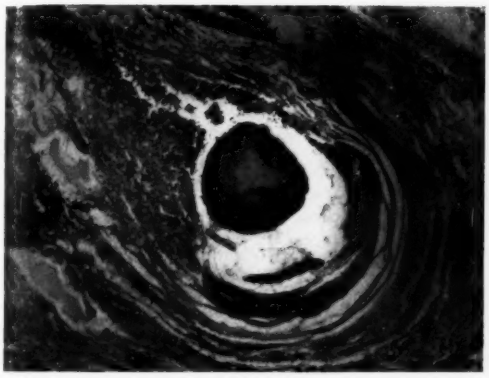


Fig. 9.

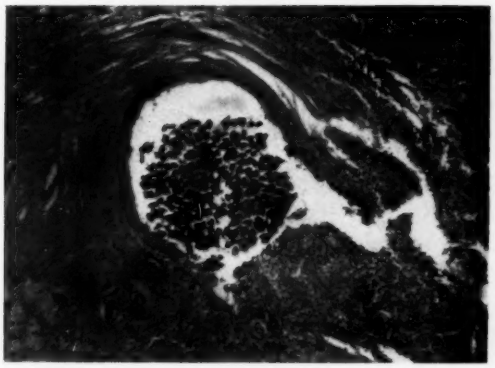


Fig. 10.

Fig. 11.

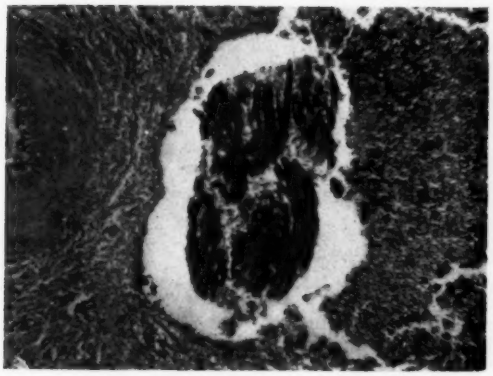


Fig. 12.

95 per cent) resorption of the petechial hemorrhages. One redundant loop is present, probably due to poor technique in the operation, because the mucosa is perfectly clean and healthy at the point of entrance and exit of the loop. In the silk specimen much of the traumatic hemorrhage is still present and 4 loops with early redundancy are seen. The wound shows more edema.

Four days: In the catgut specimen, the wound is clean with little evidence of edema or petechial hemorrhage. The silk wound has much edema, petechial hemorrhage, and many long redundant loops with evidence of mucosal sloughing from pressure necrosis at their points of entrance and exit.

Five days: The No. ooooo wound is perfectly clean with four small redundant loops whose points of entrance and exit show no evidence of necrosis. The No. oooo silk wound shows much delayed healing, delayed petechial resorption, much edema, 12 redundant loops with surrounding tissue necrosis.

Seven days: The catgut wound is perfectly healed with almost no evidence of the suture line in 60 per cent of its circumference (Fig. 3). The silk wound is fairly clean with a few areas of necrosis still present but edema still notable. Many long redundant loops are present; undoubtedly these must have sloughed through their original entrance areas to have become so long (Fig. 4).

Ten days: The catgut wound is healed—perfectly clean (Fig. 5). The silk wound still shows areas of necrosis along the suture line, and redundant loops are present (Fig. 6).

Fourteen days: The catgut wound is healed—perfectly clean (Fig. 7). The silk wound is now healed but has several areas of necrosis and many long redundant luminal loops (Fig. 8).

Microscopic appearance. Two days: Intact cross section of No. 00000 chromic catgut in submucosa with slight leucocytic reaction in one third of its perimetry (Fig. 9). Intact cross section of silk in submucosa with slight leucocytic reaction in one-third of its periphery (Fig. 10).

Three days: Intact cross section of No. 00000 chromic catgut in submucosa with very slight leucocytic infiltration. Intact cross section of silk in submucosa with minimal leucocytic invasion.

Four days: Intact cross section of catgut in mucosa with no tissue reaction. Intact cross section of silk in submucosa with slight leucocytic reaction.

Five days: Intact cross section of No. 00000 chromic catgut in submucosa with minimal tissue reaction and early fibrosis. Intact cross section of silk in submucosa with moderate leucocytic reaction and early fibrosis.

Seven days: Intact tangential section of catgut in submucosa with moderate tissue reaction and early fibrosis (Fig. 11). Intact tangential section of silk in submucosa with heavy leucocytic reaction and slight beginning fibrosis (Fig. 12).

Ten days: Intact cross section of catgut in mucosa with minimal tissue reaction and minimal fibrosis (Fig. 13). Intact tangential section of silk at sloughing point of emergence from mucosa. Note dense leucocytic reaction in silk and surrounding tissue (Fig. 14).

Fourteen days: Intact tangential section of No. 00000 chromic catgut with minimal fibrosis and very little leucocytic reaction (Fig. 15). Intact cross section of No. 0000 silk with dense leucocytic reaction and slight degree of fibrosis (Fig. 16).

RESULTS

When comparative sizes of fine silk and fine catgut are used, the catgut, having more body, can be managed with greater ease at the operating table. Fine catgut also causes less tissue trauma in transit than fine silk because of its single smooth strand as contrasted with the many twisted strands of silk.

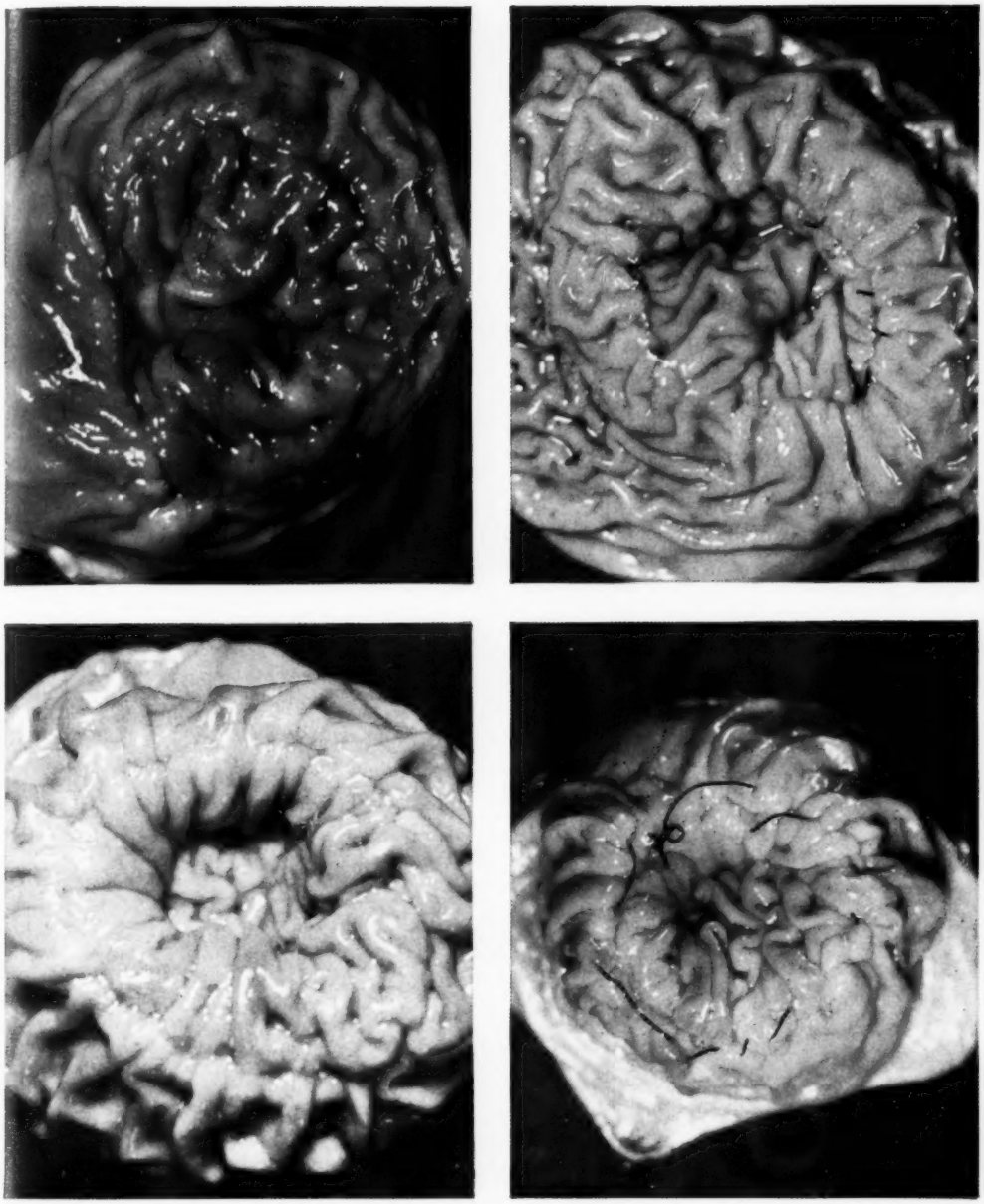
The gross appearance of the wound showed a much faster rate of healing with catgut than with silk. An outstanding and constant feature was the sloughing of the silk through the gastric mucosa, presumably due to pressure necrosis. This was shown by the presence of long redundant intraluminal loops of silk with areas of necrosis at their points of entrance and exit, as well as between them. Similar loops of silk in the gastric lumen of patients have been noted gastroscopically by us as well as by others (11) after gastric surgery where silk had been used.

Microscopically, there was much greater cellular reaction with No. 0000 black silk than with No. 00000 chromic catgut, particularly toward the end of the series. This reaction appears to be caused by pressure necrosis, so marked in the gross specimens and further evidenced by the redundant intraluminal loops.

EVALUATION

This paper is limited to a consideration of the mucosal suture. Grossly, the mucosal suture lines of fine catgut exhibited less inflammatory reaction than those in which fine silk was used. The wounds showed a much faster rate of healing when catgut was used. An outstanding and constant feature was the sloughing of the silk through the gastric mucosa, presumably due to pressure necrosis induced by the silk because of its nonabsorbability. This was noted in the earliest specimens at the end of 48 hours and increased each 24 hours, as shown by the longer intraluminal silk loops.

It is obvious that the tensile strength of any suture material need never exceed the tensile strength of the tissues (5, 12) it holds; and, if tension is exerted on a wound greater than the tissue strength but less than the suture strength, the sutures will tear through their insertions. Certainly a mucosal suture is merely an approximating suture of redundant loose tissue and may be likened to the inner plastering of a house after the firm brickwork of the outside has been completed. The serosa-muscularis suture, on the other hand, is the supporting masonry of the exterior.



Figs. 5 and 6, above—ten days
Figs. 7 and 8, below—fourteen days

The Superiority of Fine Catgut over Fine Silk as a Mucosal Suture in Gastric Surgery.—John O. Bower and A. E. Pearce.

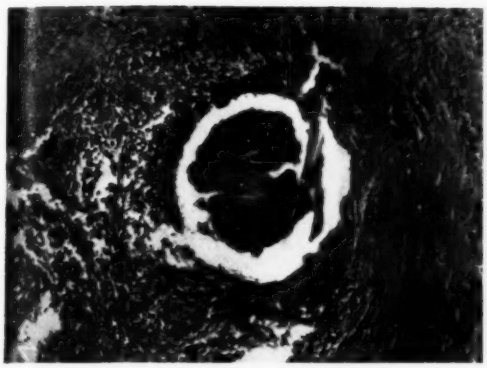
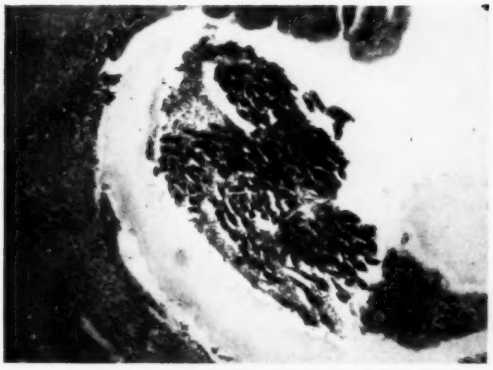


Fig. 13.



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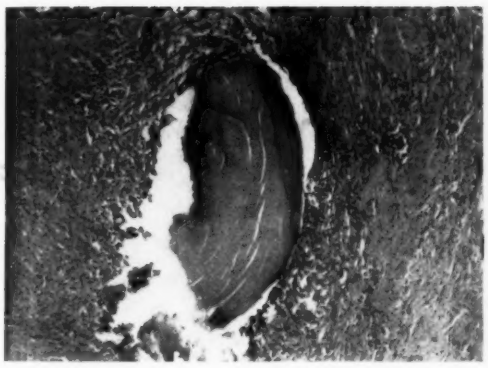

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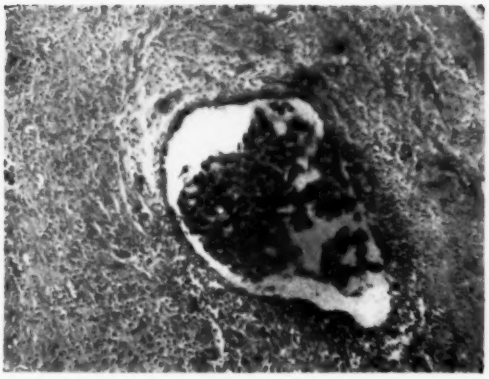

Fig. 16.

Certain it is that the use of a continuous mucosal suture of silk stands contradictory to some of Halsted's five tenets first stressed in 1913:

"(1) Use transfixion ligature, as finer material can be used by such a method; (2) use silk not coarser than No. C; (3) use interrupted sutures; (4) use a greater number of fine stitches rather than a few coarse ones; and (5) avoid the combined use of silk and catgut."

Moreover, Halsted emphasized the use of silk in clean wounds, which is an impossibility in the alimentary mucous membrane.

We have demonstrated that, when fine silk sutures are used, gross tissue necrosis is present in the mucous membrane long after the healing process has subsided in the wounds sutured with fine chromic catgut. It is obvious, therefore, that there is more danger of intramural infection from the contaminating contents of the gastrointestinal tract when silk is used. The ideal suture material for the mucous membrane is one that seals it as quickly as possible and permits it to remain sealed. Bower, Burns, and Mengle showed that divided capillaries inosculate as early as 4 days after suture of previously divided gastric mucous membrane of young dogs. Absorbable fine chromic catgut is superior to nonabsorbable fine silk in this respect.

CONCLUSIONS

1. Fine chromic catgut is more easily handled than silk of the same caliber.

2. The tissue reaction to fine silk in the mucosa resembles the reaction toward a

markedly foreign irritant. It is especially noticeable after 2 or 3 days when the unabsorbed silk produces pressure necrosis with sloughing of the mucous membrane.

3. Wound healing of the mucosa is more rapid when fine chromic catgut is used.

4. Fine absorbable catgut, designated No. 00000 medium chromic, having an average diameter of 0.006 inch, has been shown to be superior to fine, nonabsorbable black silk of equivalent size (No. 0000, diameter 0.006 inch) as a suture material for the mucous membrane of the stomach, because the silk produces pressure necrosis at the site of insertion with subsequent sloughing—as shown by redundant intraluminal loops.

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ARTERIOGRAPHY OF ABDOMINAL ORGANS BY AORTIC INJECTION

A Preliminary Report

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IN this communication we shall deal with our experiences in making 73 renoabdominal arteriograms—roentgenologic delineations of the renal and abdominal arteries after aortic injection of a radio-opaque medium. By visualizing the arteries and thus tracing the blood supply, we demonstrate the location and size of the organs.

Information thus obtained is of great aid in the diagnosis of certain abdominal masses and tumors. Our arteriograms show that an abnormal contour or caliber of the arteries is concomitant with certain diseases of the arterial tree or organs. Sometimes the arteries of an organ containing a tumor or an inflammatory process are of larger caliber than normal. On the contrary, when there is sclerosis or fibrosis of an organ, the caliber of its arteries is diminished. Tortuosity of the arteries usually means arteriosclerosis.

Further, in cases of duplication of the renal pelvis—when one unit is so diseased as to necessitate heminephrectomy—arteriography is of value, as it is also in certain cases of aberrant blood vessels in relation to hydronephrosis. Arterial aneurysms are readily visualized by this procedure.

The most striking results appear in arteriograms of vascular neoplasms of kidney or suprarenal gland; in such cases pooling of the opaque medium in the blood sinuses is shown and is pathognomonic of these tumors. In papillary tumors of the renal pelvis and in other renal tumors without blood sinuses, such pooling or laking of course does not occur.

Much of the pioneer work concerning arteriography by aortic injection was done by Santos, Lamas, and Caldas (28). They have performed more than 2,000 aortic punctures for arteriography, and many more to medicate the blood stream for various types of infection. These clinicians have also done outstanding work in roentgenography of the peripheral arteries.

The literature contains many articles on the subject, of which only a few were accessible to us. Castellanos and Pereiras describe a method of obtaining roentgenograms of the cardiac chambers and thoracic aorta by injecting and reversing the stream in the humeral or brachial artery. These workers used a 50 per cent solution of perabrodil or thorotrast, and contended that their procedure was not harmful to the intima of the arteries so injected.

As early as 1923, Berberich and Hirsch did cerebral arteriography by injecting 25 per cent solution of sodium iodide into the common carotid artery.

Arteriography of the extremities has been done with a varying degree of success. Allen and Camp (1, 2) believe that it is technically quite feasible but rarely indicated, and that in the majority of conditions of the extremities diagnosis can be made without resorting to arteriography.

TECHNIQUE

For clarity, we shall first describe the technique used, and then discuss the untoward reactions.

There are 3 important basic requirements for production of these grams: (1) the skiagraphic medium must be concentrated; (2) the injection must be completed within a few seconds; (3) the exposure of the film must be made the instant that the injection is completed.

Equipment. As injection of the opaque medium and exposure of the film must be well co-ordinated, the time element in exposure is very important. Hand-syringe injection is

Fig. 1. Pressure apparatus.

unsatisfactory, so the equipment includes a pressure apparatus for injection of the solution (Fig. 1). One also needs an 18 gauge needle about 12 centimeters long, and a supply of opaque medium. We use 80 per cent solution of sodium iodide. The x-ray machine should have potential power to deliver 500 milliamperes of current; and the Bucky diaphragm must be of the high speed type, so that exposure can be made within one-fourth of a second.

In the main, we have followed the technique devised and practiced by Santos and his co-workers.

Preparation of the patient. On the afternoon before the examination, the patient is given 2 ounces of castor oil, preferably in fruit juice with a little soda, or 2 ounces of castor oil in root beer. Thereafter he is allowed only liquid nourishment, containing a minimum amount of fruit juice and sugar.

It is well to make a trial film before the aortic puncture, when the patient is supine, to show whether the patient is in proper position and the x-ray technique satisfactory. When this has been established, the patient is anesthetized; we prefer pentothal sodium.

The aortic puncture. After anesthesia has advanced so that reflexes are abolished, the left side of the back and lower chest are prepared by tincture of iodine and draped with sterile towels.

The aorta normally lies along the left border of the vertebral column. Therefore, if a needle is passed from the back close to, and a few centimeters beyond, the body of a lower thoracic vertebra, it will enter the aorta. Figure 2 illustrates aortic puncture.

For arteriography of the kidneys and upper abdomen, the needle is passed through the skin below the twelfth rib and three finger breadths to the left of the spinous processes. It is then directed toward the body of the twelfth thoracic vertebra. As soon as that bone is encountered, the point of the needle is deviated slightly laterally, so as to pass over the vertebra. When that is accomplished, the stilet is removed, and the needle gradually advanced a few more centimeters. Entrance into the aorta is signalized by blood coming through the needle. The needle is then advanced 1 more centimeter.

After one has advanced the needle, and still observes free flow of blood, he can be certain that the needle is well within the aorta.

Injection of contrast medium and exposure of film. When the needle has been adjusted, the pressure apparatus containing the opaque medium is attached to it. As soon as the x-ray technician is ready to make the exposure, the outlet valve on the pressure apparatus is opened, and 8 or 10 cubic centimeters of the contrast solution is allowed to flow into the aorta. If the pressure is set at one atmosphere or higher, it takes only a few seconds to inject 8 or 10 cubic centimeters of 80 per cent sodium iodide. It is our practice to signal the x-ray technician to make the exposure just before the valve on the pressure apparatus is closed. After the film has been exposed, the pressure apparatus is detached from the needle, and a few cubic centimeters of blood is allowed to run out. Then the needle is withdrawn.

At The Swedish Hospital Dr. Blake has devised a lead shield over the Bucky diaphragm,

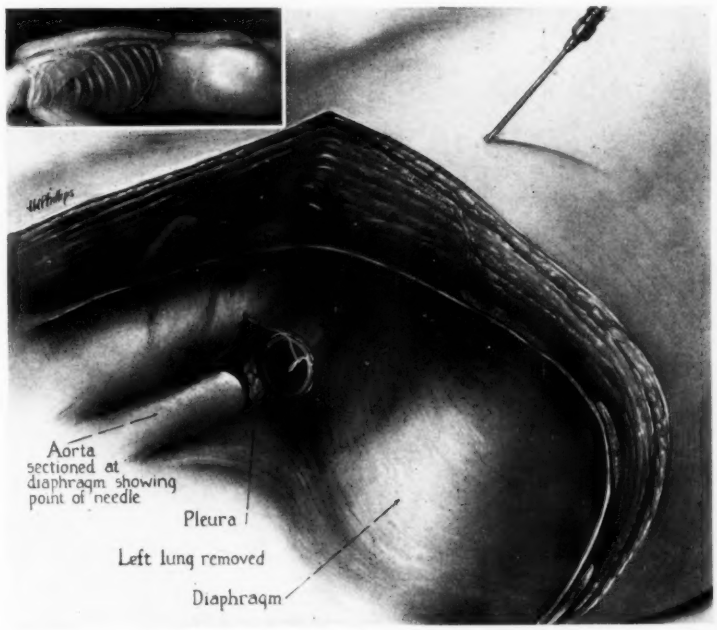

Fig. 2. Aortic puncture.

so that two films can be exposed at very short intervals. Such an arrangement gives us two chances to get a good film.

Although tourniquets on the thighs to constrict arterial flow at the time of injection are advised by Santos, we have not used them.

UNTOWARD REACTIONS AND COMPLICATIONS

Iodism. On first learning of this procedure, one is likely to believe it is beset with frequent and severe untoward reaction. The only complication we have encountered is acute iodism.

As the flow of blood is very rapid through the aorta and its abdominal branches, the sodium iodide solution must be rather concentrated to give visualization of the smaller arteries; and about 8 or 10 cubic centimeters of it must be used. Consequently, the dose of sodium iodide is rather large. Acute iodism occurred in 4 patients in our series; but in none were the symptoms alarming. In fact, we have seen more severe iodism following excretory pyelography with an organic iodide solution, than after arteriography with sodium iodide.

Santos contends—and we believe it a fact—that a person can tolerate much larger doses of iodide, if it is injected into the aorta and goes through the capillary bed, than if injected into the vein or taken orally. We have seen patients who could not tolerate 1 gram of sodium or potassium iodide after meals three times a day, who had no disturbance from 10 grams of sodium iodide given into the aorta.

We have tried to ascertain whether sodium iodide in the aorta causes irritation of the intima of the arteries. We have studied histologically the arteries of kidneys removed immediately after the injection, and also the arteries of those removed some days after arteriography. In none were we able to find any evidence of change in the intima or arterial wall from the sodium iodide.

We tried to use skiodan, and also 70 per cent diodrast, for contrast media; but the iodide content of these substances is too low to produce satisfactory pictures. Nevertheless some interesting films came out of that work. After injecting 70 per cent diodrast we

Fig. 3. Arteriogram of normal arterial tree. *a*, Aorta; *b*, splenic; *c*, gastrohepatic; *d*, renal; *e*, mesenteric, arteries.

Fig. 4. Pooling, *x*, of opaque medium outlines right renal tumor.

obtained marvellous excretory pyeloureterograms in patients whose renal function was too deficient to give satisfactory films after intravenous injection, and whose ureters could not be catheterized. Another type of interesting roentgenograms was developed, in that some films show the outline of the renal parenchyma, making what we call renograms.

At present we have a biological chemist trying to ascertain the tolerance for sodium iodide injected into the aorta and the capillary bed, as compared with that when injected into the vein or taken by mouth.

We also have another chemist working on the problem of elimination of iodide through the kidneys after aortic injection, so that we may compare findings with iodide elimination after intravenous or oral administration.

While untoward reaction from the iodide has been neither severe nor frequent, it is to us the hazardous part of this procedure. We hope that in the near future a more satisfactory contrast medium will be found.

Injury to the aortic wall. Aortic puncture is not the formidable procedure it might seem. It should be remembered that the aorta has a thicker wall, and will stand more trauma, than any other blood vessel in the human body. It is a fact, that in all the inadvertent aortic punctures made in attempting to produce splanchnic anesthesia complications are practically unknown. For a blowout or hematoma to occur from an aortic puncture, the opening in the aortic wall must be large.

It goes without saying that anyone wishing to do an aortic puncture should familiarize himself very thoroughly with the anatomical parts involved, by doing several anatomical dissections. He should practice aortic puncture in the anatomical laboratory before puncturing the aorta in the living person. Santos advises against doing this on the dog, contending that it is not comparable to the human being as to arterial anatomy and physiology.

Extravasation of contrast solution. One complication that might seem dangerous is

Fig. 5. Malignant tumor of right suprarenal gland. Note enlarged suprarenal artery, *a*, and pooling of medium *x*.

Fig. 6. Solitary cyst of left kidney. Note wide separation of spleen and kidney.

extravasation of the opaque medium. But it has been found that 8 or 10 cubic centimeters of hypertonic sodium iodide solution is readily absorbed. Such an accident occurred twice in our early work. We now ascertain the position of the needle within the aorta before the injection is started. One of these accidents occurred in a patient suffering from melanotic sarcomatosis, who had a huge mass in the liver. He stated that there was no particular increase in the pain or backache after extravasation of 10 cubic centimeters of sodium iodide. The other patient was a woman in rather poor general condition. Because of her hirsutism and hypertension, an arteriogram was made to ascertain whether she had an adrenal tumor. After the periaortic injection, the right suprarenal gland was explored. At that operation the pleura was inadvertently opened. The patient suffered a massive collapse of the lung, and died on the third postoperative day. Postmortem examination showed that massive collapse of the lung was the cause of death. There was a basophilic tumor of the pituitary gland. The tissue at the site at which the injection of iodide was made was red, but there was no evidence of necrosis.

It is not advisable to drain or explore, if periaortic injection occurs.

Our series of cases is yet too small to draw any definite conclusions. It is our impression that the procedure is valuable in certain diagnostic problems, and that it will yield information not obtainable by any other form of x-ray examination, nor even by surgical exploration; for even though a surgeon has a kidney in his hand, it is difficult at times for him to make a diagnosis with any degree of certainty.

The untoward reaction and suffering from arteriography of this type are usually less frequent and less severe than after retrograde pyelography.

Fig. 7. Pancreatic cyst. Although pyelogram was suggestive of renal tumor, arteriogram refutes that diagnosis.

Fig. 8. Splenomegalia. Note the course of arteries in the spleen, *a*.

CASE HISTORIES

In order to make our interpretations of the arteriograms clear, we shall describe them. Figure 3 shows a practically normal arterial tree of the organs in the upper abdomen.

Figure 4, case of Mrs. L. C., aged 64. Patient gave a history of having had hematuria and pain in the abdomen, of 5 weeks' duration. Examination revealed a mass in the right kidney region, and gross hematuria; but no organisms were found in the urine. Study showed a normal left kidney. The right ureter could not be catheterized. Consequently arteriography was recommended and done. The film showed a huge vascular tumor of the kidney. Findings at operation confirmed the diagnosis.

Figure 5, case of Miss N. Z., aged 29 years. Patient had marked hirsutism of 2 years' duration. Although she had gained about 40 pounds in that time, she had also had progressive weakness. Blood pressure was 180/130, and excretory pyelograms showed no abnormality of the urinary tract. An arteriogram showed a malignant tumor of the right adrenal gland. This tumor weighed 720 grams when removed at operation.

Figure 6, case of Mrs. A. G. M., aged 59 years, who underwent arteriography on August 15, 1937. A few days before that time, retrograde pyelograms had been made, which were suggestive of left renal neoplasm, with no history of hematuria or other clinical findings conforming to that diagnosis. Arteriogram showed upward displacement of the spleen and downward displacement of the kidney, without blood vessels in the intervening tissue. From these findings diagnosis of renal or pancreatic cyst was made. Two months later the operative finding was solitary cyst of the superior pole of the kidney.

Figure 7, case of Mrs. G. L. C., aged 42 years, who was referred on account of a dull, aching pain in the left side of the abdomen, where a cystic mass about 6 centimeters in diameter could be palpated. There was a history of gross blood in the urine. Laboratory findings showed many red blood cells. Secretory pyelograms left us in doubt whether we were dealing with a renal tumor.

The arteriogram showed the mass to be extrarenal. Diagnosis of a pancreatic cyst was confirmed at operation.

Figure 8, case of Mr. J. H., Russian farmer, aged 64 years, who entered The Swedish Hospital April 22, 1940. During the year previous to coming, he

Fig. 9. Large left hydronephrosis. The blood vessels can be traced going on outside of hydronephrotic sac. The outline of the parenchyma of right kidney can be seen.

Fig. 10. A large calculus of right kidney. The arteriogram shows that there is a good blood supply to the kidney.

had had attacks of diarrhea and had noticed progressive weakness. For several months he had noted a mass in the left side of the abdomen. Pyelogram showed marked downward displacement of the left kidney with pyelectasis that was suggestive, but not diagnostic, of renal neoplasm. In the arteriogram the arteries in the spleen can be traced over the outline of the soft tissue shadow, showing that we were dealing with a case of splenomegalia. At the time the patient entered the hospital, the blood count was not definitely for polycythemia vera, but later showed the red count markedly elevated.

The following case is included to show the contrast between splenomegalia, pancreatic and renal cysts, and hydronephrosis.

Figure 9, case of Mrs. A. N. L., aged 31 years, who was referred for study because of pyuria and a mass and pain in the left side of the abdomen. During the last 3 years before our examination she had also had attacks of pain in the right kidney region. The urine contained many pus cells, with mixed pyogenic infection. Renal study showed, on the right side, a fair degree of renal function as measured by indigocarmine. The pyelograms showed a moderately large hydronephrosis, and an obstruction at the pelvoureter junction. On the left side, no urine could be obtained, and there was no evidence of dye secretion in 25 minutes. On this side all of the opaque medium injected for pyelography returned around the catheter into the bladder. The arteriogram showed the renal artery extending over a huge mass, without any of the blood supply going into the mass—which proved that we were dealing with an extensive hydronephrosis. After a plastic operation to correct the obstruction on the right side, a large hydronephrotic sac on the left side was removed. There was no evidence of parenchymal tissue.

Figure 10, case of Mrs. C. L., aged 60 years, who was referred for study and operation on account of pyuria and a shadow on the x-ray film of a large stone in the right kidney. The calculus filled the pelvis and calices of the kidney. The left kidney and ureter were normal. As the function of the kidney containing the stone could not be definitely ascertained, arteriography was advised and performed. The film showed ample blood supply to the kidney. However, at the operation nephrectomy was performed since it was found that the stone was very adherent to the mucosa of the kidney pelvis and calices.

Fig. 11. Atrophic pyelonephritis. Note the complete blockage of the left renal artery at the border of the splenic artery. The tortuosity of the aorta connotes advanced arteriosclerosis.

The patient has been examined about every 6 months since the operation, nearly 4 years ago. The urine and blood pressure have remained normal, and she feels well.

Figure 11, case of Mrs. F. L., aged 42 years, who gave a history of having had nosebleed on several occasions during the months previous to coming to the clinic on January 31, 1941. She was also extremely nervous. The salient points in the findings were pyuria and a blood pressure of 240/160. Renal study showed a practically normal kidney on the right side, an atrophic pyelonephritis on the left. It seemed likely that we were dealing with a case of Goldblatt's kidney. The arteriogram showed obstruction in the renal artery a short distance from the aorta, and an attempt at establishing collateral circulation; for it can be seen that small arteries bud out from the stem of the obstructed renal artery. The marked tortuosity of the aorta made it clear that she had advanced arteriosclerosis, a condition likely making hypertension irreversible. Four weeks after the arteriography, left nephrectomy was performed. However, there has been no material change in the blood pressure, as it remains about 200/150. Her clinical condition, symptomatically at least, has improved.

SUMMARY

1. Arteriography of the upper abdomen is discussed. We have mentioned some of its advantages as a diagnostic procedure.
2. The technique is described.
3. Untoward reaction as a result of the procedure is discussed.
4. A small series of the arteriograms is shown, and our interpretation of them is given.

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SPONDYLITIS ADOLESCENS—STRUEMPELL-MARIE DISEASE

Practical and Theoretical Considerations

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A PAPER by Scott, entitled "Spondylitis Adolescens with Associated Pathological Changes in the Sacroiliac Joints," was the inspiration for the present study. Scott suggested the name "spondylitis adolescens" for the ankylosing spinal arthritis which is found in young adults. And he was of the opinion that "wide field" radiation offered hope for patients suffering from this condition.

Spondylitis adolescens, designated variously as Struempell-Marie's disease, Bechterew's disease, ankylosing spondylitis, spondylose rhizomélique, and spondylitis ankylopoetica, has for many years been differentiated from other types of arthritis. Yet this progressive and crippling disease, which ultimately leads to permanent deformity of the spine, had baffled all efforts to stop its course or to decrease the suffering and misery it causes until the introduction of roentgen therapy. When, however, the etiology and the pathology of this disease is considered, a number of questions arise. Why is spondylitis adolescens in the vast majority of instances to be found in young and otherwise healthy males? Why have pronounced changes already taken place in the sacroiliac joints, and often without the patient's having realized that anything is wrong, when symptoms of back pain first appear? Can a disease which is believed to be the result of an infectious process cause extensive destruction without giving rise to local pain or a general reaction? Why does this disease always involve both sacroiliac joints? Why are the sacroiliac joints, the spine, and occasionally the hip joints alone usually involved? Why are other joints ordinarily immune? Why if fusion has taken place in a hip joint and arthroplasty is attempted does immediate bony ankylosis occur? According to Buckley, Nelaton attempted arthroplasty three times on one patient, but even after muscle had been imposed union took place. Is some metabolic process responsible for the destruction of connective tissue and cartilage? Iritis also occurs in this disease. Does a disturbance of the metabolic process control this?

In the present study, an attempt has been made to answer some of the questions raised. An attempt has also been made to determine the physiological action of roentgen rays inasmuch as in the cases reported herein, as well as elsewhere, roentgen therapy relieved pain and apparently also shortened the course of the spondylitis.

GENERAL CONSIDERATIONS

The clinical course of spondylitis adolescens is of long duration. The disease starts in early adolescence with indefinite low back pain and continues over many years with periods of remission and exacerbation. Pain may first be noticed at the age of 12, and ankylosis of the entire spine may not take place until the patient is 25 years of age or older. With ankylosis the active part of the disease is thought to be at an end. The previous clinical history at the time of the first examination may be short—a month or 6 months. Yet roentgenograms usually show advanced changes in the sacroiliac joints, indicating that these changes do not necessarily cause pain, disability, or other symptoms.

The erythrocyte sedimentation rate is usually increased in spondylitis adolescens, sometimes to a considerable degree. Apparently this increase is proportionate to the extent of involvement and the amount of activity visible in the roentgenograms. The sedimentation rate is said to indicate the infectious etiology of spondylitis. Inasmuch as the exact relationship of the sedimentation phenomenon and infection is not known, and inasmuch as the sedimentation rate is also in-

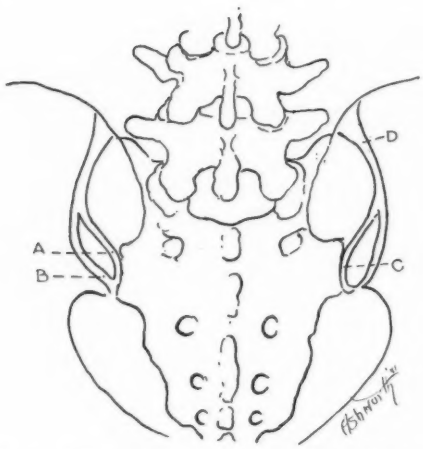

Fig. 1. Outline of the normal sacroiliac joints of an adult. *A*, posterior fissure; *B*, anterior fissure; *C*, cartilaginous section; *D*, fibrous section (Scott).

creased in other destructive conditions, such an assumption is tenable only as presumptive evidence. The patients under my observation had all been healthy young individuals prior to the onset of back pain, and some had been subjected to rigorous examinations for foci of infection. The search for infection had been followed by all the usual types of treatment—removal of tonsils and suspicious teeth, sinus operations, stool cultures, vaccine, and all forms of physiotherapy and supports. In no instance, however, had the course of the spondylitis been shortened. In spite of the varied treatment, more and more joints had become involved, flexion of the spine had increased, and the disease had progressed until complete ankylosis had taken place.

If a general metabolic change is responsible for the absorption of cartilage, it is reasonable to suppose that absorption would begin in an area of low vitality. Disease or destruction of a joint produces immobilization in that joint. Although immobilization is nature's method of relieving pain, it accelerates the absorption of cartilage and the atrophy of bone. And the process spreads until ultimately all cartilage is absorbed and bony ankylosis supervenes. The sacroiliac joints contain large amounts of cartilage. Normally there is very little movement in these joints. The tissues here, therefore, are of low relative vitality. In spondylitis adolescens the sacroiliac joints are the first to be attacked by the fixation process. Fixation next takes place at the lower spinal segments because the muscles that control their movements to some extent also control the movements of the sacroiliac joints. Eventually the process extends to all the joints of the spine with the exception of the upper two cervical segments. And the cervical segments are spared because movements of the head or neck are normally relatively excessive. This progressive fixation is carried out in the same sequence in the hip joints. Movements of rotation and abduction are the first to be lost and are the least disabling because they are used least often in ordinary activity. Movements of flexion and extension are the last to be lost because they are used most often.

Roentgenographic examination is depended upon for an insight into the pathology of spondylitis adolescens since there are no early autopsies. The first abnormal change noted in the roentgenograms is a widening and an irregular fuzziness of the sacroiliac joints. Areas of localized bone absorption occur nearby, or general atrophy of the adjacent sacrum or ilium ensues. This, however, is usually "spotty" in character. The cartilage is absorbed, the joints as such disappear, and bony ankylosis takes place. This is usually followed by increased density of the bones in the sacroiliac region. The same process takes place in the remainder of the spine. The posterolateral articulations disappear as their cartilage is absorbed. The bodies of the vertebrae show considerable halisteresis. And as remission takes place, it is seen that the supporting ligaments have been involved since they become calcified and later ossified. This calcification and ossification do not appear to spread to other soft tissues in the body. The intervertebral discs do not lose width but show more or less calcification. Bechterew described a similar disease which involved the dorsal vertebrae first. One of the patients in the present group is thus classified. It is significant that both sacroiliac joints were involved when this patient first complained of thoracic pain. Scott called attention to the fact that there is as yet no satisfactory explanation for

Fig. 2, a and b. Advanced case of spondylitis adolescens with complete ankylosis of the hip joints, sacroiliac joints, and spine. It will be noted that the cartilage in the sacroiliac joints has been completely absorbed and is replaced by what is apparently normal bone. In the lateral view of the spine, a, it is seen that the width of the intervertebral discs has not changed.

the absence of sacroiliac pain during the active period of the disease.

ROENTGEN THERAPY

In Scott's opinion, roentgen therapy brings about some beneficial constitutional effect which suggests stimulation, or the reverse, of the ductless gland system. He advised that roentgen therapy for spondylitis adolescens be instituted early. But he warned against the use of high voltage roentgen therapy, and stated that serious damage could be done if large doses were used.

Smyth, Freyberg, and Peck called attention to the fact that subjective benefit following roentgen therapy may be of psychogenic origin. They reported 15 cases of spondylitis rhizomélique in which roentgen therapy had been used. In 74 per cent of these cases there was definite subjective and objective evidence of benefit, and in 67 per cent the beneficial results were permanent. After careful search for a reason why roentgen therapy is beneficial, they did not even find a theoretical explanation for its use. And they concluded that "the rationale for employment of roentgen therapy in rheumatic disease and its *modus operandi*" was a complete mystery to them.

In the present series of cases the "wide field" technique described by Scott was followed. The roentgen rays were of medium wave length, were passed through thin filters, and were distributed over a large body area. Treatments were given twice a week for 16 doses, the total dosage being 1000 roentgens. When it was deemed necessary, the treatment was repeated. There were no serious reactions of any kind. Some of the patients complained of slight nausea, but the treatments caused no real inconvenience. No other therapy was used. Vaccine, physiotherapy, braces when possible, and all analgesics were abandoned so that a better estimate of the results might be made.

It is generally realized that remissions do take place in spondylitis adolescens and that

Fig. 3, a and b. Two brothers with spondylitis. Although both of these patients were subjected to rigorous examinations, no infectious foci were found.

spontaneous recovery may take place; also, that the course of this disease is from 10 to 20 years, and that sufficient time has perhaps not yet elapsed to evaluate properly the results from roentgen therapy. On the other hand, reports in the literature show an increasing number of encouraging results following the use of irradiation for this condition. Even though the present series is small, and it has been only 4 years since the first treatment was given, improvement has been so consistent in the comparatively early cases that it is felt the results obtained are worthy of being reported.

CASE REPORTS

CASE 1. W. H., male, aged 24 years, was first seen on January 3, 1938, complaining of pain which had appeared first in the left hip then in the right,

Fig. 4. Following arthroplasty there is a definite tendency for ankylosis to take place. The roentgenogram illustrates this phenomenon.

stiffness of the back, and pain under the costal margins. Symptoms were of 3½ years' duration.

The first irradiation treatment was given on December 9, 1938. The patient felt worse after this. Therapy, however, was continued, and the series of 16 treatments was completed on January 31, 1930. Three days later the pain was no better than it had been at the start of the roentgen therapy. Improvement, however, was noticed within a few weeks, and continued over the succeeding 2 years. The patient was employed steadily, played tennis and golf, and went swimming. He had only an occasional twinge of pain.

Roentgenographic findings. The first roentgenogram, which the patient brought with him, had been taken on December 30, 1935. It was an anteroposterior view, and showed an irregular outline of the sacroiliac joints and roughening of the lower lumbar posterolateral joints. Roentgenogram on January 4, 1938 showed considerable increase of the irregularity of these joints. The joint spaces were widened, and the adjacent bone was mottled. In some areas the bone was dense, in others atrophic. The bodies of the last 2 lumbar vertebrae had a fuzzy appearance. The posterolateral joints were not visible. On January 24, 1941, 2 years after irradiation, roentgenogram showed the sacroiliac joints to be completely fused. Bone striations had approached normal, and the increased density had disappeared. The texture of the vertebral bodies had lost its fuzzy appearance. And the two lower vertebral joints appeared to be ankylosed.

This boy's condition had grown progressively worse until he was treated with roentgen rays. Since then his symptoms continued to decrease. Roentgenograms revealed that the

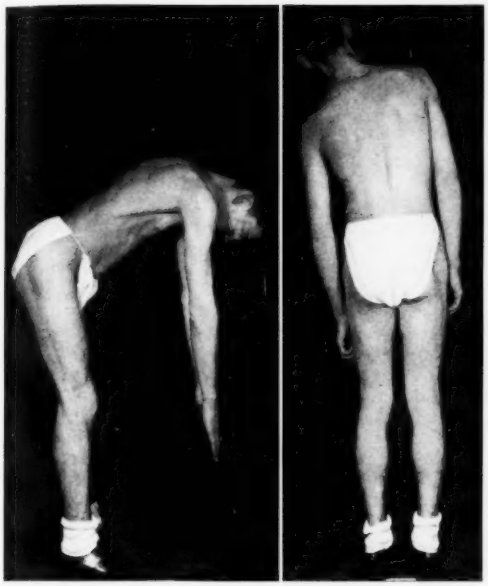

Fig. 5, a and b. These photographs were taken some months after a course of roentgen therapy. There were no complaints of pain at that time, but rather pronounced rigidity was still present. At the beginning of the treatment this boy was walking on crutches because of pain.

texture of the bone in the involved areas had improved considerably. Ankylosis of the involved joints had, however, continued. It may be argued that this is a natural recession, as sometimes occurs in this disease. It was not caused by the psychologic effect of treatment since improvement did not take place until after the treatment was stopped.

CASE 2. A. G., male, aged 18 years, was first seen on December 16, 1935 because of painful feet. At that time the patient had no symptoms referable to the back. On September 15, 1938, however, he complained of severe back pain with stiffness of the back and hips and flexion of the hips and spine.

A series of 16 roentgen treatments was started on March 14, 1939. This was followed by striking symptomatic relief, but the stiffness of the back and hips remained the same. On October 23, 1939, he returned. He was walking with the aid of crutches, and complained of severe pain in the lower back. Another series of roentgen treatments was started. Improvement during this treatment course was remarkable. Within a week the crutches were discarded. On January 18, 1940, the patient reported that he had no pain. He had gained 20 pounds. There was increase in the movements of the hips,

Fig. 6. While there are definite abnormal changes in the sacroiliac joints shown here, the changes consist only of irregularity of the anterior fissure and sclerosis of the adjacent bone, the ilia, and the sacrum. This indicates that spondylitis may not progress to complete ankylosis.

and probably also of the spine although this is difficult to estimate.

CASE 3. B. C., male, aged 15 years, was first seen on June 5, 1940, complaining of back pain of 1 year's duration. No other joints were involved. The tonsils had been removed.

Examination revealed loss of normal lumbar lordosis. There was a slight flexion deformity of the hips (psoas spasm). The hip movements were normal otherwise, except for slight restriction of external rotation. Roentgenograms were normal except for slight irregularity of the sacroiliac joints and some widening. The bone texture was good. There was no evidence of involvement of the posterolateral vertebral joints from the roentgenographic standpoint, but clinical findings were very definite.

After 4 roentgen treatments the patient was not so stiff as he had been. Improvement continued without interruption. This patient, who had been so disabled that he could not take part in games or sports, was playing football by October, 1940. He had no pain, and almost all of his back stiffness had disappeared by that time. Roentgenograms taken on June 2, 1941, showed normal sacroiliac joints. There was no clinical evidence of disability, and there were no complaints. This boy gained 15 or 20 pounds, and was in excellent health.

CASE 4. D. MacD., male, was first seen when he was 32 years old. When he was 16, he had noticed pain and swelling in his feet. Later he had also had pain in his back. No other joints had been involved.

Roentgenograms revealed extensive involvement of the bones of the pelvis and of the entire spine. Atrophy was pronounced. There was also fusion of the sacroiliac joints, some deformity of the pelvis, and ankylosis of the spine.

On December 8, 1938, roentgen therapy was started. After the first 8 treatments roentgenograms

Fig. 7. Myositis ossificans of long standing. This patient suffered for many years with spondylitis adolescens. About the time of the onset of his spinal symptoms he also developed the condition in his thigh which is shown in this roentgenogram. Some disturbance of the heparin content of the blood or the tissues may be responsible for this process.

showed beginning collapse of some of the vertebral bodies. This collapse had taken place while the patient was wearing a Taylor back brace and during the time he was being given radiotherapy. Treatments were stopped. The patient, however, began to improve. He gained 20 pounds, and the swelling of his feet subsided. On November 28, 1940, treatments were resumed, and 16 were given. Roentgenograms of the lumbar spine on April 1, 1941, showed that recalcification was taking place. The patient's general condition at that time was greatly improved. His appetite was better, the pain was less severe, and he was able to return to his work as a salesman.

Improvement in this instance took place at a time when retrogression of symptoms might be expected. Nevertheless, the improvement seems to have been directly associated with the roentgen therapy since no improvement had occurred with any other form of treatment. It is of interest to note that this patient's brother also had spondylitis adolescens. The brother, however, had no irradiation, and the disease progressed to ankylosis in spite of every known type of therapy.

CASE 5. A. R., male, aged 23 years, was first seen on April 20, 1939. In 1936 this patient had injured his back. He had taken 20 chiropractic treatments, but in spite of this he had become almost completely disabled. On December 10, 1938, 4½ months before admission, he had again injured his back while lifting a sack of wheat and throwing it into a car. Following this he had pain across his hips.

Examination revealed stiffness of the spine and muscle spasm. There was some interference with straight leg raising. Roentgenograms showed irregularity of the sacroiliac joints with sclerosis of the adjacent bone and some decrease in definite markings of the lower lumbar posterolateral articulations.

Irradiation was started on April 20, 1939. On June 23 the patient returned to work. On December 21, 1939, he reported that he had twisted his back and that this had caused a return of the pain. He stated, however, that the roentgen therapy had done him a great deal of good, that it had taken much of the stiffness out of his back, and that he did not have the catches in his hips and back that he had had before.

Both sacroiliac joints of this patient were abnormal. The changes, however, consisted only of an irregularity of the joint outlines. It is possible that in some instances spondylitis adolescens does not progress to ankylosis.

RELATIONSHIP OF MAST CELLS AND HEPARIN TO SPONDYLITIS ADOLESCENS

It has been demonstrated that the mast cells of Ehrlich are present in wide distribution in the body and are especially abundant in the connective tissue surrounding blood vessels. It has also been shown that the distribution of these cells is proportionate to the abundance of heparin in the various organs. Holmgren and Wilander found that heparin is contained in the granules of the mast cells. Before this, Lison had observed that the presence of mucoitin and chondroitin sulfuric acids is responsible for the metachromatic reaction shown by mucoid and cartilaginous tissues when stained with toluidine blue, and that this staining reaction is specific for these sulfur acid esters of high molecular weight. And Jorpes pointed out that heparin, which is a polysulfuric ester with a high molecular

weight, gives a color "a hundred times stronger than that obtained with the same quantity of chondroitin sulphuric acid," . . . also, that "toluidine blue possesses an extremely strong affinity for heparin."

In an excellent and exhaustive review of the chemistry, physiology, and clinical application of heparin, Mason called attention to the fact that "the ester sulfate content of tissues was found to parallel its content in mast cells, as was the content of crude heparin. The morphologic and chemical observations," he stated, "all strongly support the conclusion that (1) the metachromatic granules in these cells contain heparin, (2) that the cells have secretory activity, and (3) that their function is to supply the circulation with the physiologic anticoagulant." Mason cited the important studies carried out by Jorpes and his associates on the chemistry of heparin, and he summarized Jorpes' chief contentions as follows: Heparin is a mucoitin polysulfuric ester of variable composition—these variables being the number of sulfuric acid groups substituted into the individual mucoitin units, the degree of polymerization (the number of mucoitin sulfuric acid units which are linked together to form its polysaccharide structure), and the relative esterification of each unit. Chondroitin and mucoitin sulfuric acids, Mason explained, "are the prosthetic groups of the corresponding chondroproteins and mucoproteins. They consist of units of an hexuronic acid, presumably glycuronic, an amino sugar, sulfuric and acetic acids. The acetic acid is present as an N-acetyl group on the amino sugar, and sulfuric acid, one or more moles, is bound by an ester linkage to the free hydroxyl groups of the hexuronic acid and/or the hexosamine, the latter being galactosamine in chondroitinsulfuric acid and glucosamine in mucoitinsulfuric acid."

Cartilage is composed of approximately 70 per cent water, 28 per cent organic solids, and 2 per cent inorganic matter. The organic solids are for the most part chondroitin sulfuric acid. Chondroitin sulfuric acid is found not only in cartilage but also in tendons, ligaments, aorta, sclera, and probably, according to Levene, in osseomucoid. Logan stated that the conversion of cartilage to organic matrix

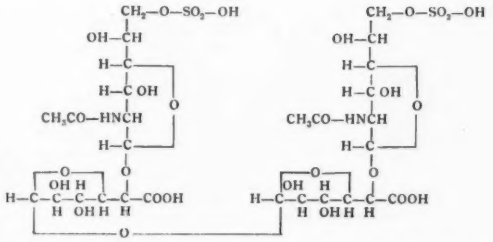

Fig. 8. Structural formula of chondroitin sulfuric acid (Levene). Chondroitin sulfuric acid contains galactosamine. Mucoitin sulfuric acid (heparin) contains glucosamine. The hydroxyl on the fourth carbon of the hexosamine group is inverted in mucoitin sulfuric acid as compared with chondroitin sulfuric acid. These compounds are closely allied in their physical and chemical properties.

of bone is characterized by the loss of organic sulfates.

Tumors such as carcinoma are surrounded by a great number of mast cells. After treatment with high voltage roentgen therapy the mast cells disappear. Sylvén attempted to determine what happened to mast cells after such therapy, and conducted experiments on rats. The animals were covered with lead plates except for a field on the abdominal wall measuring 5 by 5 centimeters. Two series of animals were given 1000 and 1500 roentgens, respectively, in one treatment. One or two days after irradiation there appeared in all connective tissue of the corium and the subcutis substances exhibiting metachromatic staining reaction. These substances were diffusely distributed in the cell territories of the fibroblasts. Sylvén observed that after treatment of low dosage, 1000 and 1500 roentgens, a great many granules in the mast cells had disappeared, but there had been no increase or decrease in the number of mast cells. The results indicate that some of the sulfuric acids in the granules was excreted from the cytoplasm of the mast cells and spread diffusely over the surrounding connective tissue after exposure to roentgen rays. The threshold dose seems to be less than 1000 roentgens. Smyth *et al.* used 600 roentgens in 3 doses in treating spondylitis.

IRITIS

It has been noted by many observers that iritis occasionally occurs during the course of

spondylitis adolescens. In the cornea there are normally very few mast cells, but during the course of an infection, such as a serpiginous ulcer, the number of these cells increases. There is also an increase of the mast cells in the eye when iritis and glaucoma occur. The aqueous and vitreous humors consist of mucoitin sulfuric acid. The fact therefore that the eye is composed of substances closely related to the chondroitin sulfuric acid of cartilage, together with the fact that the eye is involved during the course of spondylitis adolescens, indicates a direct relationship of metabolic origin. Furthermore, the increase of the mast cells may be an effort toward healing. Ehrlich in 1879 stated that these cells were related to the nutrition of tissues. Because of this he labelled them "mast" (food) cells.

EVALUATION

It would seem logical to believe (1) that the pathological changes which occur in spondylitis adolescens are caused by an absorption of cartilage and not by an infectious process; (2) that the beneficial results obtained from the generalized exposure of the body to roentgen-ray dosage of medium wave length is brought about by the liberation of sulfur within the body in such a form that it can replenish a sulfur deficiency in any part of the body; (3) that in spondylitis adolescens chondroitin sulfuric acid is absorbed from the cartilage, ligaments, and bone in and around the sacroiliac joints and spine; and (4) that this absorption probably occurs because of a deficiency of sulfur or mucoitin or chondroitin sulfuric acids elsewhere in the body. It is of interest to note that Cawadias in 1925 stated that it is not illogical to assume that a certain hereditary or constitutional predisposition exists for sulfur demineralization. He expressed the belief that sulfur demineralization is a special metabolic disturbance in rheumatoid arthritis, and that the tissues in this condition lose the power which they have of retaining sulfur.

SUMMARY

1. Cartilage consists of chondroitin sulfuric acid, a substance like mucoitin sulfuric acid.

2. Mast cells contain granules composed of mucoitin sulfuric acid. These cells are located mostly in the connective tissue around blood vessels as well as in synovial tissue.

3. Irradiation causes mast cells to give up their sulfuric ester granules.

4. Roentgen-ray dosage of comparable strength gives striking relief of the symptoms associated with spondylitis adolescens.

5. The hypotheses are presented (1) that spondylitis adolescens is caused primarily by an absorption of cartilage from the joints involved and not by an infectious process; (2) that the beneficial results of roentgen therapy are brought about apparently by liberation of sulfur within the body in a usable form; and (3) that iritis, a condition associated with spondylitis, is caused by the same metabolic disturbance and possibly may react favorably to the same treatment.

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A CLINICAL AND PATHOLOGICAL STUDY OF LEIOMYOSARCOMA, HEMANGIOENDOTHELIOMA OR ANGIOSARCOMA, AND FIBROSARCOMA OF THE STOMACH

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A GREAT deal has been written on the subject of sarcoma of the stomach, although it is a comparatively uncommon lesion. Much confusion has resulted from the lack of a uniform nomenclature and classification for these tumors. It is our belief that the leiomyosarcomas, hemangioendotheliomas and fibrosarcomas of the stomach comprise a group of nonepithelial neoplasms quite distinct clinically and pathologically from the group of lymphosarcomas. The purpose of this paper is to correlate the clinical and pathological features of sarcoma of the stomach with special reference to the foregoing three types and to present a simplified classification.

Fourteen histologically proved cases of gastric sarcoma, exclusive of lymphosarcoma, in which operation was performed at the Mayo Clinic between 1908 and 1938 inclusive, have formed the basis for this paper.

The first case of sarcoma of the stomach in the literature was that recorded by Bruch in 1847. In 1901 Fenwick reported 53 proved cases of sarcoma of the stomach and in 1914 Forni made a complete analysis of the subject, bringing the total cases reported to 200. A review of the literature in 1930 by D'Aunoy and Zoeller increased this figure to 335 cases.

ETIOLOGY

As in all forms of malignant lesion, very little is known concerning the causation of gastric sarcoma. Various hypotheses have been advanced but in general it may be said that probably no single specific factor is responsible for the origin of sarcoma. Trauma, inflammation, or some form of chronic irritation is believed to act on normal tissue cells, benign tumors, ulcers, or congenital isolated cell rests of the stomach to produce proliferation of mesoblastic cells and ultimately sarcomatous change.

Trauma is thought to play an important etiological rôle. Numerous cases are cited in which the patient associated the onset of symptoms with some form of trauma, and such observers as Brooks, Sherrill and Graves, and McWhorter have called attention to this relationship.

Farr explained the relative infrequency of sarcoma of the stomach as compared with carcinoma by the fact that the connective tissue elements of the stomach from which sarcoma takes its origin are less exposed to injury than the carcinoma forming epithelial surfaces which are exposed constantly to chemical and mechanical assault.

Some observers contend that sarcomas do not develop from previously normal cells but rather from congenital cell rests, but this contention has not been proved. Mallory stated that hemangioendotheliomas are often congenital and frequently, perhaps always, arise from abnormalities of the blood vessels.

There is little doubt that sarcomatous change does occur occasionally in benign gastric tumors and may even take place rarely in chronic gastric ulcers. This relationship has not been proved satisfactorily but has been suggested many times. D'Aunoy and Zoeller claimed that it is theoretically possible because gastric ulcers can stimulate prolonged formation of connective tissue, and such chronic reactions to irritation have been shown conclusively to act as etiological factors in the production of malignant processes in other organs.

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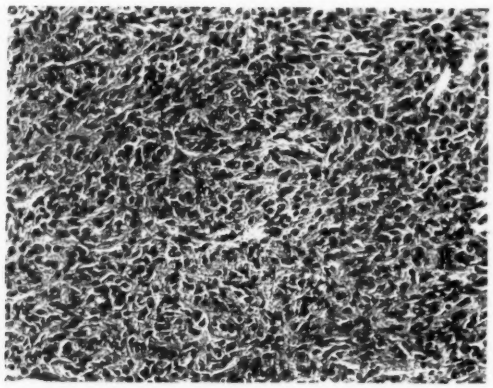
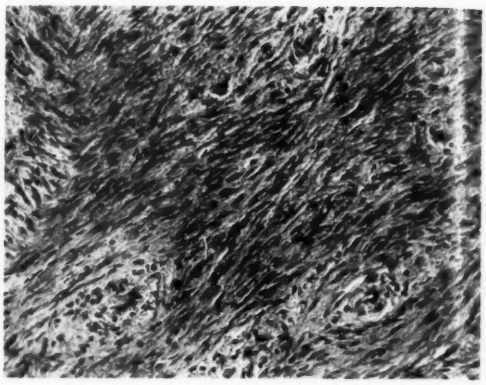


Fig. 1



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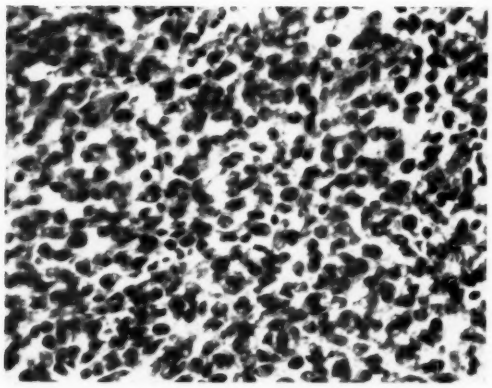

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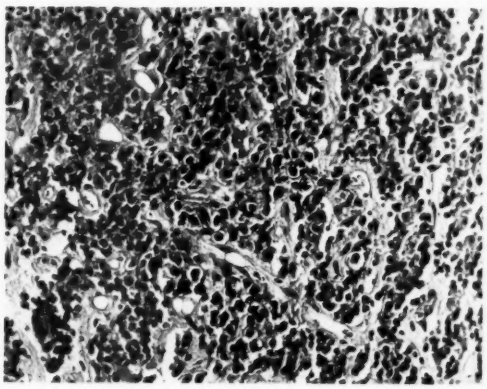

Fig. 4

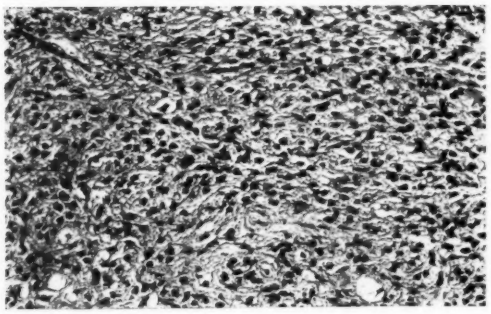

Fig. 5

Fig. 1. Leiomyosarcoma of the stomach of low grade malignancy (hematoxylin and eosin, ×130).

Fig. 2. Benign leiomyoma of the stomach showing mature smooth muscle tissue in its characteristic arrangement. No mitotic figures are present (hematoxylin and eosin, ×130).

Fig. 3. Highly malignant leiomyosarcoma of the stomach. Note the wildly growing, highly undifferentiated cells and the presence of mitotic figures (hematoxylin and eosin, ×314).

Fig. 4. Hemangioendothelioma, or angiosarcoma, of the stomach. Notice how the endothelial cells, in an attempt to form new vessels, have arranged themselves into cord-like structures some of which have already been canalized and contain erythrocytes (hematoxylin and eosin, ×130).

Fig. 5. Fibrosarcoma of the stomach with myxomatous changes (hematoxylin and eosin, ×130).

In this series 8 of 14 patients, or 57.1 per cent, had one or more reasonably definite features of ulcer. These consisted of periodicity, epigastric pain coming on after meals, relief of pain after ingestion of food and alkali, nocturnal pain, and a history of previous roentgenological diagnosis of ulcer. The preoperative clinical diagnosis in 2 cases was peptic ulcer, while in 3 cases a roentgenological diagnosis of ulcer had been made previously.

Incidence. Sarcoma has been estimated variously to comprise from 1 to 8 per cent of all neoplasms of the stomach. Ewing estimated its frequency at 1 per cent, while Fenwick expressed the opinion that it comprises from 5 to 8 per cent of all gastric neoplasms.

Age. Sarcoma of the stomach affects all age groups, although the period between 40 and 60 years of age comprises the largest group. The youngest patient appearing in the literature is that reported by Finlayson: a child 3 years of age with a fatal outcome 6 months later. The oldest patient, 91 years of age, was reported by Di Giacomo.

The average age of patients who have gastric sarcoma is considerably less than that estimated for carcinoma. Douglas quoted the average age for gastric carcinoma from the United States census figures as 61.2 years.

In this series the average age of the patients was 43.2 years, the youngest being 10 years of age. Almost half of our patients fell in the age group of 40 to 50 years. In 11 of our 14 cases the lesion was leiomyosarcoma; the average age of the patients was 46.6 years. There were 2 cases of hemangioendothelioma, in which the patients were 10 years and 29 years of age, respectively. In the case of fibrosarcoma the patient was 54 years old.

Sex. The average reports in the literature state that the sex is divided about equally, although such observers as Balfour and McCann, and D'Aunoy and Zoeller report a preponderence in males.

In our 14 cases, 9 of the patients, or 64.3 per cent, were males and 5, or 35.7 per cent, were females. Only 3 of the 11 leiomyosarcomas were found in females while both of our cases of hemangioendothelioma were in females. The 1 case of fibrosarcoma occurred in a male.

PATHOLOGY

Attempts to classify sarcomas of the stomach pathologically have met with varying degrees of success. Seventeen different classifications have been encountered in the literature and these appear to have little uniformity.

It is apparent, therefore, that some simple inclusive classification should be decided on. It is recognized fairly generally that lymphosarcomas make up a definite class of gastric tumors, not only clinically and pathologically, but also in regard to their treatment and prognosis. The remaining types of gastric sarcoma, which comprise about a fourth of the total number, may be divided into three groups: leiomyosarcoma, hemangioendothelioma or angiosarcoma, and fibrosarcoma.

Frequency. Confusion exists regarding the relative frequency of the different histological types of gastric sarcoma. Fenwick stated that lymphosarcoma comprises 62 per cent of the sarcomas of the stomach, fibrosarcoma, 22 per cent of the cases, and leiomyosarcoma and angiosarcoma make up the remainder.

In Balfour and McCann's 54 cases, lymphosarcoma comprised 71.3 per cent, fibrosarcoma 13.3 per cent, and myosarcoma 6.7 per cent.

In reviewing our specimens, it was found that 11 of them, or 78.6 per cent, were leiomyosarcomas, 2 were hemangioendotheliomas, and 1 was a fibrosarcoma. These figures seem reasonable because of the abundance of smooth muscle tissue in the stomach as compared with the amount of vascular endothelial tissue and fibrous connective tissue present, although they are contrary to the general belief that fibrosarcoma is next in frequency to lymphosarcoma of the stomach.

Location. The location of these tumors is a fairly constant feature. They differ from carcinoma in that they rarely involve the orifices. Ewing stated that they usually arise from the curvatures, rarely from the pylorus, may project into the peritoneum, remain interstitial, or protrude into the cavity of the organ.

Balfour and McCann concluded that the lesser curvature is involved chiefly and the lesion is situated usually in the antrum, rarely at the pylorus, and never in the cardia.

The location of the tumor was determined in all of our cases and bears out the fact that

these lesions are found most frequently arising from the lesser curvature of the stomach, in which location they occurred 5 times. Other locations were encountered in the following order: posterior wall, 3 times; anterior wall, greater curvature, and pyloric end of stomach, each 2 times.

Gross characteristics. Sarcomas of the stomach vary considerably in their gross characteristics, depending on their cell of origin, location, and rapidity of growth. Generally speaking, they are fairly rapidly growing tumors with a tendency to grow expansively in the connective tissue and vascular framework of the organ rather than to grow by infiltration as is so common with carcinomas.

The types of sarcoma under discussion here usually are sharply limited from the surrounding normal tissue, although a true capsule usually is wanting. They are usually highly vascular and for this reason often reach an enormous size. One of the largest was that reported by Cantwell, which weighed 12 pounds (5.4 kilograms).

Because of their rapid growth and great size attained, secondary changes are encountered frequently. Some of these, such as edema, hemorrhage, and mucoid degeneration, tend to increase the bulk of the lesion further. When the limit of growth is reached, as determined by the blood supply, infarction and necrosis occur. Infection may follow and often accounts for the febrile course seen in certain cases of gastric sarcoma. Degenerative cysts and abscesses likewise may form. Perforation is fairly common. Hesse stated that perforation occurs in 8 per cent of cases.

Ulceration of the mucous membrane occurs late in the course of the disease and is usually the result of pressure necrosis, the mucosa not being involved primarily in the growth. Hemorrhage occurs either in the gastric lumen or in the tumor itself as a result of ulceration and rupture or thrombosis of the blood vessels.

Leiomyosarcoma originates in the smooth muscle cells of the muscularis, is fairly slow growing, and usually is well demarcated from the rest of the gastric layers.

Hemangioendothelioma has its origin in the endothelial cells of blood vessels. Being a connective tissue tumor, it can be classed as a sarcoma. Grossly, it may simulate leiomyosarcoma and fibrosarcoma very closely and is usually well circumscribed, frequently pedunculated, and but rarely infiltrating.

Fibrosarcoma of the stomach takes its origin from the wall, most frequently in the submucosa. It rarely assumes the form of an infiltrating growth and usually remains as a well demarcated intramural tumor.

These types may remain confined to the stomach wall as intramural growths, but, more frequently, they grow inward or outward to form sessile or pedunculated endogastric or exogastric tumors. The exogastric is perhaps the most common form, and, because of the relative ease of its surgical removal and its slowness to metastasize, it is considered less malignant than the endogastric or infiltrating forms.

Microscopic characteristics. The histological appearance of sarcoma varies considerably but usually resembles that of its tissue of origin. In the slower growing, well differentiated tumors, little difficulty is encountered in diagnosis but, with increasing anaplasia, the form of their originating cells is lost and classification may be difficult. The cells themselves may be divided into two groups for all sarcomas of the stomach, namely, round cells and spindle cells. These may be subdivided further into small and large round cell or spindle cell sarcomas. These different cell types may be present alone or in combinations in any of the four types of sarcoma. As a rule, however, the round cells are confined to the lymphosarcoma type, while the spindle cells make up the leiomyosarcomas, hemangioendotheliomas, and fibrosarcomas.

The microscopic picture of leiomyosarcoma consists of immature smooth muscle cells of varying degrees of differentiation grouped into interlacing bundles and bands separated by a fibrous stroma whose amount depends on the compactness of the tumor structure. When of low grade malignancy (Fig. 1) these tumors appear very similar to benign leiomyomas (Fig. 2) and frequently one is mistaken for the other. The finding of mitotic figures, however, establishes the malignant nature of the lesion (Fig. 3).

Microscopically, hemangioendothelioma are composed of large oval or spindle shaped endothelial cells arranged in a manner attempting to form new blood vessels (Fig. 4). These are very vascular tumors containing numerous blood spaces and sinuses filled with erythrocytes. Their cells are usually quite mature and therefore they are easily confused with benign hemangiomas. Here, again, the presence of mitotic figures establishes the diagnosis of malignancy.

The fibrosarcoma is made up of connective tissue cells varying in appearance from that of immature fusiform fibroblasts to that of almost mature fibrous connective tissue cells (Fig. 5). The same general interlacing pattern is noted. The cells themselves usually are elongated, oval, or spindle shaped with large granular nuclei. Mitotic figures are always present.

Degree of malignancy. As in all types of malignant tumors, the degree of malignancy of these gastric sarcomas varies according to the proliferative activity and differentiation of their cells. As a general rule they are less malignant than lymphosarcomas, not only in regard to cellular proliferation but also because they are usually noninfiltrating, more or less circumscribed, and often pedunculated growths which are more easily extirpated surgically.

Metastasis. Metastasis has been estimated variously by different observers as occurring in from a third to three-fourths of all cases of gastric sarcoma.

Most authors agree that metastasis occurs most often in the regional lymph nodes of the stomach and in the liver. The liver was involved by secondary deposits at the time of operation in 3 cases, or 21.4 per cent, in this series. In each of these 3 cases the location of the metastatic deposits was noted as being in the liver, and in 2 of them, metastatic nodules were found in the omentum and peritoneum, respectively. In 1 of these inoperable cases, the involvement of the liver was not found until operation; the abdomen was closed after a specimen for biopsy had been secured from the tumor, which proved to be a hemangioendothelioma. More than 6 years later this same patient returned to the clinic and exploration was performed again. Metastatic deposits were found again in the liver and, this time, also in the omentum. A biopsy was made which confirmed the first report, and no further surgical intervention was attempted. The patient died about 6 months after the last operation. In 2 of the operable cases metastasis was reported in the liver 6 years and 3 years, respectively, after operation, which brings the total known metastatic growths in the liver to 5 cases, or 35.7 per cent.

CLINICAL MANIFESTATIONS

The clinical manifestations of sarcoma of the stomach generally are considered indistinguishable from those of any other malignant or sometimes benign tumor of the stomach. The sarcomas are confused most often with gastric carcinoma, peptic ulcer, and benign bleeding gastric leiomyomas.

There are no definite pathognomonic signs, symptoms, or laboratory criteria on which a diagnosis of sarcoma of the stomach can be made before operation. Recognition of the malignant nature of the lesion, however, is the matter of prime importance, whereas the particular type of neoplasm is only of secondary consideration.

The onset of the disease, although usually insidious, may be sudden and the symptoms may vary from the mildest dyspepsia to the severest manifestations of gastric carcinoma.

The course of these tumors is relatively slow. In 1 of our patients, one or more gastric symptoms had been present for as long as 15 years, while 3½ years was the average duration of symptoms before medical aid was sought here. The shortest period in which symptoms had been present was 4 months.

Symptoms. The symptoms which bring the patient to seek medical aid are not generally such early ones as mild dyspepsia, epigastric distress, nausea, and anorexia. Usually it is the onset of severe abdominal pain, a rapidly enlarging abdominal mass, hemorrhage from the growth in the form of melena or hematemesis, vomiting, or marked loss of weight which brings the patient to consult his physician. By this time, of course, the disease is well advanced and secondary complications often have occurred.

Pain, hemorrhage, vomiting, and the production of severe digestive disturbances occur late in the course of the tumor after it has invaded the mucous membrane or become large enough to produce pressure necrosis and ulceration of the mucosa. Following this, cachexia soon may become manifest. Most observers agree that it occurs at a later stage in this disease than it does in carcinoma. Pain was found to be the most frequent presenting complaint; it occurred in 13 of 14 cases, or 92.9 per cent.

Nausea and vomiting were second in order of frequency and were present in 8 cases, or 57.1 per cent. In only 3 of these, or 21.4 per cent, did the patient give a history of hematemesis. In 2 of our cases the pylorus was involved in the growth but in only 1 of these did the patient complain of vomiting. No hematemesis had ever been noted in this case and the vomiting was not of the type usually seen in pyloric obstruction. Almost all observers agree that vomiting and hematemesis occur less frequently in sarcoma than they do in carcinoma of the stomach.

The presence of an abdominal tumor mass was the next most frequent finding, occurring in half of our cases. In 5 of these the mass had been discovered by either the patient or his local physician before admission to the clinic. The shortest duration of the tumor was 2 weeks, the longest 9 years, while the average duration was more than 4 years. In all cases the mass was located in the upper part of the abdomen, usually the left part of the epigastrium, and in most cases was said to be movable.

Melena occurred in 6, or 42.9 per cent, of our cases, and was the fourth most frequent complaint. Its usual duration was a few months but in 1 case it had been present intermittently for 15 years. Both Reeves and Fenwick have called attention to the frequency of hemorrhage in their patients and the latter estimates that it occurs in 50 per cent of cases.

Weakness and pallor occurred in 4 cases and were attributed to the secondary anemia present. The average concentration of hemoglobin for these cases was 46 per cent (6 grams per 100 cubic centimeters of blood). The erythrocyte count averaged less than 3,500,000 cells in each cubic millimeter of blood.

Indefinite digestive disturbances were complained of in 4 cases, or 28.6 per cent. These were variously referred to by the patient as "gas on the stomach," "heart burn," dyspepsia, or indigestion. In the majority of cases they preceded other symptoms of the disease and in 1 case they had been present for 24 years.

Loss of weight was recorded in 3, or 21.4 per cent, cases but was not striking. The loss of 25 pounds (11.3 kilograms) in approximately 2 years was the greatest decrease noted.

The remaining symptoms occurred in an occasional case and consisted of constipation, anorexia, fever, and dizziness or fainting in order of frequency. The only significant ones in this group are fever, dizziness, and fainting. Fever, though not common, was present in 3 of our cases and represented secondary infection of the tumor or formation of abscess. Dizziness and fainting were noted in 2 cases and in each case they heralded a severe gastric hemorrhage which soon became manifest by hematemesis or melena.

The arrangement of the foregoing symptoms into an ulcer pattern was noted a number of times. This was suggestive enough in 3 cases to enable a preoperative diagnosis of peptic ulcer to be made.

In a few cases the only symptoms complained of by the patient were those resulting from secondary complications of the gastric tumor. Infection, formation of abscess, perforation of the stomach, peritonitis, and other complications present typical clinical pictures with their characteristic type of pain, febrile course, and other symptoms.

Laboratory methods of diagnosis. No laboratory criteria have been established by which a definite diagnosis of gastric sarcoma can be made. Roentgenological examination is the most satisfactory, however, and while the type of malignancy may not be determined by this method, the diagnosis of a malignant gastric tumor almost always can be made. Kirklin and Weber, in discussing roentgenological diagnosis of neoplastic disease, stated that sarcoma of the stomach is rare and

"although unmistakable roentgenological evidence of the malignant nature of the process usually can be elicited, the roentgenologist is prone, on account of its comparatively low incidence, to designate the process carcinoma rather than sarcoma."

Gastroscopy has been employed recently in an effort to diagnose gastric sarcoma before operation. Schindler expressed the opinion that this condition "may present a characteristic picture in the gastroscope which is entirely different from all other diseases of the stomach." In 1 of our cases a diagnosis of recurrent sarcoma of the stomach was made gastroscopically 2 years after surgical excision of the tumor.

In former years considerable importance was attached to gastric analysis in the diagnosis of these lesions. It was believed that the amount of free hydrochloric acid was normal or excessive in gastric sarcoma and, as we know, usually absent in carcinoma of the stomach. This was used as a point of differential diagnosis. In none of our cases in which the gastric analysis was reported was there complete absence of free hydrochloric acid. All had approximately normal free and total hydrochloric acid determinations with the exception of 1 case which was slightly higher than normal. Westphalen reported a case in which he made a diagnosis of gastric sarcoma by microscopic examination of a bit of tumor tissue obtained by gastric lavage.

It would seem, then, that in order to make a diagnosis of sarcoma of the stomach, the clinical picture and laboratory findings must be considered carefully as a whole and differentiated from those characteristic of other gastric lesions without too much reliance being placed on any one particular finding. Frazier summed up the picture well by saying, "in a patient presenting gastric symptoms of several months' duration with a readily palpable, freely movable tumor of the stomach but without loss of weight, general debility and cachexia common to carcinoma of the same duration, one might be justified in suspecting sarcoma."

Differential diagnosis. In the differential diagnosis of leiomyosarcoma, hemangioendothelioma, and fibrosarcoma of the stomach, the lesion which simulates them most closely, of course, is lymphosarcoma. In view of the fact that sarcoma is practically never differentiated clinically from other malignant and, in some cases, benign lesions, it would be absurd to attempt to establish criteria here by which specific types of sarcoma could be recognized clinically.

There are, however, a few differentiating characteristics which may be mentioned. Lymphosarcoma is likely to occur in younger persons, 30 to 40 years of age, is of higher grade malignancy and so runs a more rapid course with earlier metastasis than other types of gastric sarcoma. The pylorus is involved more frequently and, while it often remains unobstructed in spite of this, disturbances of gastric motor function are more common. A palpable abdominal mass is encountered less often. Involvement of the mucosa by infiltration occurs relatively early, resulting in earlier and more severe pain and greater tendency to gastric hemorrhage, infection, and perforation. Cachexia is more severe and earlier in its occurrence. There is more likely to be an associated enlargement of the spleen, and lastly, lymphosarcoma is highly sensitive to irradiation therapy.

Carcinoma is by far the easiest lesion to confuse with sarcoma of the stomach and in most instances is practically impossible to differentiate with any degree of accuracy. Certain differentiating features exist, however, but none is conclusive. Gastric carcinoma, as a rule, occurs late in life, the average age being about 60 years. It is a tumor of epithelial origin and consequently involves the mucosa first. Because of this, ulceration with its resultant hemorrhage, infection, and perforation occurs earlier and more frequently than in gastric sarcoma. Carcinoma is usually infiltrative and involves the pylorus in about 60 per cent of the cases. For this reason symptoms of pyloric obstruction and gastric retention are much more common. Carcinoma of the stomach is a much more rapidly growing lesion than sarcoma, is more malignant, runs a considerably shorter course, metastasizes earlier, and is accompanied by more severe systemic effects such as secondary anemia, emaciation, and cachexia. A palpable

abdominal mass is less likely to be encountered unless very late in the course of carcinoma and then it usually is fixed.

There remain so many lesions which must be considered and ruled out when arriving at a diagnosis of gastric sarcoma that it is impossible to give their distinguishing features here. Of these, benign gastric ulcers are probably the most important because of their frequent occurrence. Benign leiomyomas may simulate sarcoma if they attain considerable size. These are considered the most common tumor of the stomach by Rieniets, who found them present in 16 per cent of routine necropsies. Other benign gastric lesions to be considered are pedunculated polyps and gastric syphilis.

Tumors and cysts of almost any of the abdominal viscera may be confused with gastric sarcoma. Splenomegaly, especially that occurring in Banti's disease, in which associated gastric hemorrhages and secondary anemia are common, is often difficult to differentiate from gastric sarcoma.

PROGNOSIS

The prognosis in all forms of gastric malignant neoplasia necessarily must be guarded and sarcoma is no exception to this rule. The particular type of sarcoma has a great deal of bearing, however, on the ultimate prognosis. It is accepted by most observers that the types discussed here, namely, leiomyosarcoma, hemangioendothelioma or angiosarcoma, and fibrosarcoma, offer the best prognosis.

W. J. Mayo stated that in his experience he was impressed by the longer course and better surgical results obtained in gastric sarcoma as compared with gastric carcinoma.

Hemangioendotheliomas offer the best prognosis of any of the gastric sarcomas. Cignozzi called attention to the chronic course of hemangioendotheliomas and maintained that symptoms develop gradually and are not pronounced until late in the course of the disease, and that emaciation and metastasis are absent. One of our patients was living and perfectly well when last heard from, 13 years after partial gastrectomy at the age of 10 years, for a hemangioendothelioma of the stomach.

The pedunculated form of gastric sarcoma offers a better chance of cure than the infiltrating type because it is more easily removed surgically and is usually one of the less malignant types. The diffuse infiltrating forms, almost always lymphosarcoma, are rapidly growing tumors and less amenable to surgical removal. For this reason they may offer even a worse prognosis than does carcinoma of the stomach.

In our group of 14 cases, comprising only leiomyosarcomas, hemangioendotheliomas and fibrosarcomas, 7 of the patients are known to be dead at the time of writing. Six patients were living when last heard from and 1 patient was lost track of soon after operation. Of the patients who have died, the average duration of life after operation was 3 years and 4 months. In the 6 patients who were living when last heard from, the average duration of life following operation was more than 4 years.

TREATMENT

The treatment of sarcoma of the stomach, regardless of cell type, is surgical. Leiomyosarcomas, hemangioendotheliomas and fibrosarcomas usually remain locally operable and without metastasis until rather late in their course. Counseller and Collins emphasized the fact that these tumors at first appear to be inoperable because of their size and the adherence to them of the greater omentum and viscera. They expressed the opinion, however, that the sharp line of demarcation from normal stomach wall makes extensive resection possible. For this reason Balfour and McCann recommended abdominal exploration in spite of a roentgenological report of inoperability.

Glenn and Douglas claimed that sarcoma has a better operative prognosis as a group than carcinoma and that of sarcomas, leiomyosarcoma, hemangioendothelioma, and fibrosarcoma are more amenable to surgical measures than lymphosarcoma.

In our patients partial gastric resection was carried out in 8 cases, of which 5 were of the posterior Pólya type, 1 was an anterior Pólya resection, and 2 were segmental resections. Local excision of the tumor was done in 3 cases, and 3 cases were simply abdominal explorations in which specimens for biopsy

were removed from inoperable tumors for microscopic diagnosis.

Additional surgical procedures were performed in 2 cases. In 1 of these pyloroplasty was done in addition to the segmental resection. In another in which the tumor had been excised locally gastrostomy was performed and radium was inserted.

There were no postoperative deaths in our series of 14 surgical cases. The shortest duration of life following operation was 3 months. In only 1 case was any serious postoperative complication mentioned and this was bilateral bronchopneumonia from which the patient made a satisfactory recovery.

Aside from surgical intervention, irradiation offers the only method of treatment of sarcoma of the stomach. Its field is limited, however, and it rarely proves of value in sarcomatous lesions other than lymphosarcoma. Lymphosarcoma is highly sensitive to irradiation and Desjardins stated that early lesions of this type may be cured by irradiation alone.

Repeated series of roentgen irradiation were used as an adjunct to operation in 2 of our cases, in 1 of which radium was also used as a supplement. In 1 of these cases the lesion was inoperable and the patient lived more than 6 years with metastatic growths present in the liver all the time. The other patient suffered a recurrence 2 years after operation.

SUMMARY

Fourteen histologically proved cases of gastric sarcoma, exclusive of lymphosarcoma and including 11 leiomyosarcomas, 2 hemangioendotheliomas or angiosarcomas, and 1 fibrosarcoma, in which operation has been performed at the Mayo Clinic between 1908 and 1938, inclusive, were studied clinically and pathologically.

An attempt has been made to simplify the terminology and classification of sarcoma of the stomach and to point out the clinical and pathological features distinguishing the leiomyosarcomas, hemangioendotheliomas, and fibrosarcomas as a group separate from lymphosarcoma.

CONCLUSIONS

The cause of sarcoma of the stomach is unknown. Evidence may be found pointing to its origin in normal cells, congenital isolated cell rests, traumatized or inflamed tissues, benign tumors, and gastric ulcers. Males were affected in 64.3 per cent of our cases. The average age for the group was 43.2 years.

All sarcomas of the stomach may be classified into four types: lymphosarcoma, leiomyosarcoma, hemangioendothelioma or angiosarcoma, and fibrosarcoma. The last named three most often involve the curvatures of the stomach, more rarely the pylorus or cardia. They originate in the submucous or muscularis layers of the stomach wall, are usually well circumscribed, are often pedunculated, and tend to assume an exogastric or endogastric form, although in rare cases, they may be infiltrating.

They may be composed of round cells or spindle cells, large or small, depending on the proliferative activity of the growth and the amount of cellular differentiation. Histologically the cells group themselves in a characteristic arrangement of interlacing bundles and whorls.

Leiomyosarcoma, hemangioendothelioma, and fibrosarcoma are usually of an average grade of malignancy. Metastasis occurs in about a third of the cases, the most common sites being the regional perigastric lymph nodes and the liver.

There are no pathognomonic clinical findings or laboratory criteria on which a definite diagnosis of sarcoma of the stomach can be made. The clinical and laboratory picture must be considered as a whole and the fact that the malignant nature of the lesion is recognized is the one of prime importance. The onset may be sudden or insidious. Symptoms usually appear late and the duration of symptoms before treatment averages 3½ years. The chief signs and symptoms in their order of frequency are pain, nausea and vomiting, abdominal tumor, melena, weakness and pallor, digestive disturbances, hematemesis, and loss of weight. Frequently patients give a history suggestive of peptic ulcer. No laboratory procedures are considered definitely diagnostic, although roentgenographic examination usually establishes the malignant nature of the lesion. Carcinoma of the stomach offers the greatest differential diagnostic

problem. Other lesions to be considered are benign gastric tumors and ulcers and tumors or cysts of almost all the abdominal viscera.

The prognosis, while guarded, is better than that of lymphosarcoma or carcinoma. Secondary complications, such as ulceration, hemorrhage, infection, formation of abscess, perforation, peritonitis, and metastasis, make for a much poorer prognosis. The particular cell type is a factor in the prognosis. The more mature the cells and the slower the growth, the better is the prognosis. There were no operative or immediate postoperative deaths among our 14 patients.

The treatment of choice is operation and it is the only treatment that has anything to offer in leiomyosarcoma, hemangioendothelioma, or fibrosarcoma. Lymphosarcoma responds readily to irradiation but this form of treatment is of little value in other types of gastric sarcoma.

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PNEUMONIA AS A COMPLICATION OF BILIARY COLIC

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ONE of us began to practice medicine more than 31 years ago, and almost immediately encountered cases in which the illness started as a frank attack of biliary colic and soon after developed into pneumonia. At the onset there was no fever, cough, dyspnea, or abnormal physical signs in the lungs. On the contrary, severe epigastric or right upper quadrant pain prompted the patient to seek help; the pneumonia came as an unpleasant surprise to us and to the patient's family. While the usual abdominal complications of biliary colic had been explained, we did not expect the complication of pneumonia which proved to be most annoying and at times even hazardous. About 20 years ago one of our patients, a middle aged woman, died of pneumonia although the coexisting gall-bladder attack had subsided. During the first 15 years, in a large general practice, no time or opportunity was afforded to study this problem. We kept no record of the cases, but there must have been 6 or possibly 9 during that period. The case referred to was the only one we can remember which terminated fatally. As a result of this experience we began to fear pneumonia more than the other better known complications, and it was always a source of amazement to us that neither the current medical literature nor discussions in medical societies made mention of this complication.

However, during the past 16 years we have had an opportunity to practice in a hospital, and this has given us a better chance to study such cases. Laboratory facilities were also thus available, in addition to knowledge obtainable from cases of other members of the staff. As a result of our study we have become convinced that our early impressions were correct.

A search of our hospital files for the years 1921 to 1940 revealed 11 instances which exemplify the complication here described. A number of other cases of biliary disease with pneumonia were noted, but the histories failed to reveal the sequence of events described so they are not included here. Cases of postoperative pneumonia were properly excluded, although it seemed to us that in many instances the pneumonia probably existed before the operation.

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CASE 1. No. 108367. R. G., female, aged 48 years. She had had an attack of biliary colic 4 years ago. On October 6, 1940, the patient was seized with an attack, in the right upper quadrant of the abdomen, of severe pain which radiated to the back. She vomited several times. An injection of morphine was given. The next day she had another similar attack, for which she again received morphine. The temperature was normal and the lungs were clear. The pain continued. She then began to cough a little, but there was no expectoration. On October 10 the patient was admitted to the surgical service of the Beth-El Hospital with a diagnosis of acute cholecystitis. The temperature on admission was 104 degrees F., the pulse was 120, and the respirations, 42 per minute. Bronchovesicular breathing and moist râles were heard over both lower lobes posteriorly, more on the right than on the left. The gall bladder was greatly enlarged, reaching almost to the iliac crest, and was very tender. The patient was transferred to the medical service. X-ray examination of the chest confirmed the clinical diagnosis of bilateral pneumonia. The white blood cells numbered 17,700 with 86 per cent polymorphonuclear cells. The blood culture was negative. Sulfapyridine was given, but was discontinued on October 14 because of the appearance of jaundice and bile in the urine. Oxygen was also given. The temperature came down to normal by October 12. On October 15 she had another attack of biliary colic which required morphine. Following this her temperature rose to 102 degrees F. On October 24 there was another rise in temperature following another attack of colic. The pulmonary signs gradually cleared up, but the gall-bladder remained palpable. A flat plate of the gall-bladder region on October 20 revealed numerous gall stones.

It is noteworthy that although this patient was extremely ill she had only a slight cough and no expectoration at all. She refused operation and was discharged on November 4, 1940.

CASE 2. No. 28542. L. E., female, aged 60 years. Illness began on June 1, 1928, with pain in the right upper quadrant of the abdomen. On June 9. there

was pain in the left lower chest. The next day, the patient began to cough and expectorated bloody sputum. She was admitted to the hospital on June 13. The gall bladder was enlarged and tender, and there was consolidation of both lower lobes, more extensive on the left side. Two days later an x-ray examination of the lungs showed a slight haziness of the left base. The temperature reached normal in 6 days, and the patient made an uneventful recovery.

CASE 3. No. 861. R. K., female, aged 36 years. This patient gave a history of repeated attacks of biliary colic with jaundice extending over several years. Her present illness began on August 6, 1921, with a typical attack of biliary colic. On August 10 she began to cough, and the temperature rose to 102 degrees F. She was admitted to the hospital on the following day with a large tender gall bladder and with pneumonia of the right lower lobe. The patient made an uneventful recovery.

CASE 4. No. 85690. Z. C., female, aged 47 years. One year before admission to the hospital the patient had a typical attack of biliary colic. Her present illness began on August 15, 1937, with diarrhea, chills, fever, and headache; 24 hours later she developed severe abdominal pain which became localized to the right upper quadrant of the abdomen. Morphine was administered. Two days later she was admitted to the hospital. The gall bladder was enlarged and tender; the lungs were clear. Three days later there was a definite pneumonia of the left lower lobe, and 2 days after that the right lower lobe also became involved in the pneumonic process. An x-ray film confirmed the diagnosis of bilateral pneumonia. The gall bladder increased in size, reaching almost down to the iliac crest, and the leucocyte count rose to 21,000, with 80 per cent polymorphonuclear cells. An operation was advised. However, the patient refused operation and signed herself out of the hospital on August 26. (We learned later that the symptoms gradually subsided and the patient got well, without operation).

CASE 5. No. 96907. A. A., female, aged 70 years. The patient had an attack of biliary colic 6 years ago and another attack 3 months ago. The present illness began on April 20, 1939, with pain in the right upper quadrant of the abdomen. On examination a large, tender gall bladder was found. On April 25 she was admitted to the hospital. In addition to the large gall bladder, a lag of the right chest was noted, and a few râles were heard at the right base. Within the next few days she developed a full-blown pneumonia involving the entire right lung and the left lower lobe. This was confirmed by an x-ray film of the chest. There was very little cough and no sputum. The patient made an uneventful recovery and left the hospital on May 5, 1939.

A search of the literature pertaining to this subject revealed very little. Neither textbooks on general medicine nor special books on the gall bladder make mention of pneumonia as a complication of biliary colic. The most recent book on this subject (6), published in 1940, discusses at great length the various complications of biliary disease, but entirely omits pneumonia. Carter, Greene and Twiss describe "impairment of resonance and diminution of breath sounds" due to elevation of the diaphragm secondary to subdiaphragmatic pathology. Wilkie states that due to the "rigidity of the right half of the diaphragm, as proved by x-ray examination, the picture may, therefore, resemble a primary right sided lung affection. The chill at the onset, the thoracic pain, the catch in the breathing, combined with the fact that, owing to the immobile diaphragm and deficient expansion of the right base, crepitations are frequently to be heard on auscultation; all these features may divert attention from the abdomen to the chest. Many of my patients gave a history of previous attacks diagnosed as congestion of the lung. The pulmonary signs should always be looked for and assessed at their true value." In 1912 Bahrdt (2) described cases of obscure fever with the physical signs of pneumonia either in the right or left, or in both bases, without the symptoms or signs of gall-bladder disease. The fever subsided but frequently recurred. Eventually gall-bladder tenderness, or perhaps icterus, developed and the diagnosis of gall-bladder disease became evident. He thinks that the gall bladder was the cause of the infection. His cases ran a protracted but mild course. However, they differ from ours, because ours began as frank attacks of biliary colic without any signs or symptoms of pneumonia. The following case is an example of the type described by Bahrdt:

CASE 6. No. 82998. A. S., female, aged 60 years. The patient gave a history of repeated attacks of biliary colic. Cough and expectoration were also present for many years. The present illness began March 12, 1937, with fever, cough and expectoration. She was admitted to the hospital on March 20. Her temperature was 101 degrees F.; pulse rate, 116; respirations, 22 per minute. X-ray examination revealed a pneumonia of the right lower lobe. Tenderness in the right upper quadrant of the abdomen was noted on admission, but this was over-

shadowed by the pneumonic symptoms. On March 22, jaundice developed and the gall bladder was found to be enlarged. The patient made an uneventful recovery.

This case makes us speculate whether a more careful history might not have revealed symptoms of biliary colic preceding the pneumonia.

In 1929, Akaiwa and Ishida reported 7 cases, a few of which are good examples of the type described by us. They called attention to the fact that "lung and bronchial inflammations very often follow biliary tract infections."

ETIOLOGY

The exact mechanism which operates to bring about inflammation of the lungs in gallbladder disease is not known. Moreover, inflammations of other abdominal organs are also frequently complicated by pneumonia. We can recall a number of instances of pyelitis and pyelonephritis in which this complication arose. We were frequently at a loss to explain the fever of long duration by the renal infection alone. A careful examination of the lungs revealed the pneumonia. When this cleared, the fever subsided. Furthermore, it is very likely that the factors which are responsible for the production of pneumonia after abdominal operations are also responsible for the pneumonia that follows intra-abdominal inflammations. Intra-abdominal infection is commonly present in both cases. Also, spasm and elevation of the diaphragm and the shallow breathing induced by morphine are present in both conditions. Pulmonary atelectasis and bronchopneumonia may then ensue. The recumbent posture makes proper feeding difficult and tends to bring about aspiration pneumonia. Waters made "An attempt to reduce to a common denominator the etiological factors involved in the production of pulmonary complications," and came to the conclusion that, "with rare exceptions, such morbidity follows a period of interference with the normal functions of the respiratory mechanism, whether due to drug action, trauma, or illness."

Direct extension of the infection through the diaphragm to the lungs is a possibility; Kehling and Kehr, according to Akaiwa and Ishida, favor this idea. However, there is no proof that this really takes place. One of Bahrdt's (3) cases came to autopsy 13 years after the pneumonia; no pathological changes were found in the right diaphragm, pleura, or lung. Akaiwa and Ishida injected pneumococci and staphylococci into the gall bladders of dogs, and succeeded in producing acute pneumonitis in some of the animals, provided the organisms were virulent and the common bile ducts were tied off. They think that the infection spreads through the blood stream. This is also Bahrdt's (3) opinion. If this were so, we would expect to find an equal distribution in all lobes. Actually, in our 11 cases as well as in those of Bahrdt and Akaiwa and Ishida, we found that although the lesion was usually bilateral, it was almost always confined to the lower lobes, with the right side predominating both in frequency and extent. In 7 of our 11 cases the lesions were bilateral, 3 involved the right lower lobe only, and 1 the left lower lobe only. While we realize that the number of cases is not sufficiently great to be significant statistically, this distribution suggests that no single factor can satisfactorily explain this complication.

CLINICAL FEATURES

One of the features which struck us particularly in these cases was the almost complete absence of cough and expectoration in most of the patients. We have no explanation for this. All 11 of the patients were females, varying in age from 29 to 70 years, with an average of 54.1 years. The interval between the onset of the biliary colic and the pneumonia was usually from 2 to 6 days, but in a few cases it was as long as 2 to 3 weeks. The white blood cell count varied from 8,400 to 21,000 (average 13,200), with from 71 to 92 per cent polymorphonuclear cells (average 83 per cent). Blood culture was done in 3 cases and was negative in each instance. Sputum typing could not be done in most of the cases because of the lack of sputum. All of the patients recovered. This we feel is noteworthy in spite of the smallness of the series, because of the advanced age of most of the patients, and the fact that they were suffering from two severe acute illnesses at the same

time. It should also be pointed out that all but one of them came under observation before the era of chemotherapy. In most of the patients the gall bladder was markedly enlarged, frequently extending almost to the level of the iliac crest. None perforated, and none was operated upon, although in several instances operation was advised but was refused.

DIAGNOSIS

It would be presumptuous for us to discuss the diagnosis of either pneumonia or biliary colic. What we do wish to bring out is that if the possibility of pneumonia as a complication of biliary colic is kept in mind, the chest will be examined more carefully and x-ray pictures taken in doubtful cases. This will perhaps forestall many "postoperative" pneumonias which are at times found suspiciously soon after the cholecystectomy is performed. Conversely, the clinical picture may be so dominated by the pneumonia that the preceding biliary symptoms may readily be overlooked. This is well illustrated by the following case history:

CASE 7. No. 89232. R. K., female, aged 66 years. The patient took sick on March 12, 1938, with severe epigastric pain which radiated to the left side of the abdomen. She vomited. She was admitted to the hospital on March 14. The temperature was 104.8 degrees F., the pulse rate was 120, and the respirations were 32 to the minute. There were diminished breath sounds, dullness, and moist râles at the base of the right lung. The abdomen was distended, and there was marked tenderness in its upper portion. Jaundice appeared on March 17, and the icterus index rose to 26.9, but the pulmonary symptoms still predominated. It was not until 2 days later, when a mass was felt in the right upper quadrant of the abdomen, that the gall bladder was suspected. X-ray films showed a bilateral bronchopneumonia, and a pathological nonfunctioning gall bladder. The patient refused operation and was discharged on April 12. Throughout her illness there was very little cough or expectoration.

As to the frequency with which this complication occurs we are not prepared to state, because it has not been generally recognized that pneumonia may follow inflammation of the gall bladder. With this in mind, more cases will most likely be found. At the present time it would be worthless to attempt a statistical study.

TREATMENT

Treatment will, of course, depend on the individual case. In some patients the gall-bladder condition may be such as to demand immediate operative intervention in spite of the presence of the pneumonia; this should then be done under local anesthesia. In most cases, however, the discovery of the pneumonia will call for postponement of the contemplated operation, and perhaps save the patient's life. On this point we disagree with Akaiwa and Ishida, who feel that the reverse is true; namely, that the removal of the gall bladder cures the pneumonia.

PREVENTION

It is, of course, difficult to make intelligent suggestions for the prevention of a condition the cause of which is not thoroughly understood. It might be helpful, however, to instruct the sufferer from biliary colic to take several deep breaths at frequent intervals to improve ventilation of the basal portions of the lung. Intermittent inhalation of carbon dioxide-oxygen mixture may be used in aged or debilitated individuals. Frequent change of position should be rigidly carried out. A more judicious use of morphine might also be of some value, substituting nitroglycerine whenever possible. Waters stresses the importance of "focussing the attention of the house staff on the extraneous pharmacological effects of pain-relieving drugs," among which not the least important is their effect on the respiratory mechanism. Finally, early operation in cases in which the gall bladder is enlarging rapidly would probably serve to prevent the pneumonia, for it is apparently in the obstructive cases that pneumonia appears most likely to develop. The recent trend for early operation (5) in acute cholecystitis thus receives further justification.

SUMMARY AND CONCLUSIONS

1. A painstaking search of the literature for the past 60 years revealed only one reference which mentioned pneumonia as a complication of biliary colic.

2. The authors are convinced that such a relationship does exist.

3. Our 11 cases support this contention.

4. The exact pathogenesis is not known, but spasm and elevation of the diaphragm, shallow breathing caused by morphine and the recumbent posture, aspiration of infected material, and spread of the infection from the gall bladder *via* the lymphatics into the blood stream and thus to the lungs, are probably the chief factors involved.

5. The usual interval between the colic and the pneumonia is from 2 to 6 days; the pneumonias have been characterized by their relatively benign course and the paucity of cough and expectoration.

6. The diagnosis is readily made if it is kept in mind that pneumonia does occur as one of the important complications of biliary colic.

7. Treatment will be directed in individual cases toward whichever condition constitutes the most serious threat to the patient's life; in most instances this will be the pneumonia.

8. Encouragement of deep breathing to improve pulmonary ventilation, use of carbon-dioxide-oxygen, frequent change of position, and a less frequent use of morphine in cases of biliary colic, and particularly early operation in cases of acute cholecystitis, may serve to prevent the development of this complication.

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STUDIES IN DIETHYLSTILBESTROL

II. Differences In Response of Radium Induced and Physiological Menopause
III. Effect on Liver

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THE need for an effective estrogenic substance that does not require parenteral administration appears to have been met with the synthesis of diethylstilbestrol (4:4-dihydroxy-alpha: beta-diethylstilbene). This compound was developed in 1938 by Dodds, Goldberg, Lawson and Robinson who showed it to be active in oil, alcohol, water, and as the acetate. They found it to be two to three times as potent as estrone under similar conditions. It bears no chemical relationship to estrone since it possesses no phenanthrene ring, but it produces almost identical physiological effects. The only biological differences that were observed were that stilbestrol has an appreciably less stimulating action on the mammary tissue than does estrone (5); that though stilbestrol, like estrone, will inhibit the comb growth in capons when injected simultaneously with androsterone, it does not inhibit comb growth when applied to the comb by inunction (9, 10). This latter phenomenon has not yet been explained. However, percutaneous absorption does occur and estrus can be produced in spayed mice whose necks are painted with stilbestrol in oil (10). Palmer and Zuckerman further showed that it was absorbed through the vaginal mucous membrane of spayed mice, causing estrus to supervene.

The action and the effect of this synthetic estrogen on the human has been the subject of reports in Europe (16) and in this country (2, 7, 15). The reports all agree as to its effective use in producing clinical improvement in the symptoms of the menopause and in producing biological changes similar to those obtained with parenteral estrone or estradiol, but they vary in their evaluation of the development of undesirable side effects. It is with justifiable trepidation, therefore, that this product was employed in preliminary studies and that its unqualified recommendation for general use was held in abeyance. Our study on several groups of patients, supplemented by laboratory observations, is presented in the hope that more information may be gained concerning the manner of its action and that a better evaluation of its indications and manner of administration may be secured.

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METHODS EMPLOYED

The stilbestrol was administered orally in varying doses to two groups of women. One group consisted of patients who were suffering from the menopause syndrome, and the other of postpartum women in whom large doses of stilbestrol were employed in order to observe its efficacy to inhibit or stop lactation. The latter group is discussed in a subsequent communication. The first group consisted of 28 menopause cases, 10 of which were radium induced, 11 surgically produced, and 7 physiological cases. The subjective symptoms of each were observed before treatment was instituted and a definite routine was followed in the course of the study. It was believed desirable to study the three types of menopause cases separately since it had been our experience that radium induced cases were generally more refractory to treatment and because such patients required considerably larger doses in order to be controlled. The patients were seen at weekly intervals for a period of 4 to 5 months. During their visits vaginal smears were done and interpreted according to the criteria of Papanicolaou and Shorr. Endometrial biopsies were performed before treatment was instituted, then again 2

TABLE I.—SIDE EFFECTS OF STILBESTROL

	No. of patients	Nausea	Vomiting	Breast pain	Abdominal or pelvic pain	Muscle cramps	Skin eruptions	Pruritus vulvae	Daily dose mgm.	Relief of menopausal symptoms—%	Bleeding response
Radium menopause	10	6	5	1	8	3	1	4	2–3	100	3
Surgical menopause	11	6	5	3	8	0	0	1	0.1–1.0	100	
Physiological menopause	7	4	1	0	6	2	0	3	.01–1.0	100	6
Total side effects	28	16	11	4	22	5	1	8			
Total recoveries		13	11	4	10	5	1	7			

weeks after treatment was started, and finally 5 weeks after beginning the administration of the stilbestrol. Urinalyses were done and the patients' subjective complaints tabulated regularly. The degree of amelioration of the menopause symptoms was observed during treatment, and the development and duration of toxic disturbances were noted simultaneously.

The radium treated patients had suffered from a bleeding dysfunction and varied in age from 42 to 50 years at the time that the radium was inserted. Previous to the radium treatment, diagnostic endometrial curettements had been done in order to rule out the possible existence of malignancy. These curettings served as a means of comparing subsequent endometrial biopsies that were secured after a period of treatment with stilbestrol. The patients were given 3 milligrams of stilbestrol daily by mouth so that a total of 114 milligrams had been administered in 5 weeks. Using a Meig's curette to secure endometrial biopsy tissue after 2 weeks' treatment, only 4 patients yielded sufficient material for examination. After 5 weeks' treatment, 8 of the 10 radium cases studied yielded enough material for examination. The 2 other patients exhibited complete closure of the external os, thus preventing the introduction of the curette. All the cases thus studied showed a proliferative nonsecretory endometrium which tended to duplicate in every way the picture of the endometrium before the radium was inserted. The modifying effect of the radium on the response of the endometrial glands, stroma, and myometrium to the stilbestrol was quite interesting and has been reported elsewhere (6). After the maximum biological effect of stilbestrol was observed, the patients were maintained on treatment for a total period of from 3 to 4 months, during which time each had received approximately 324 milligrams of the drug.

OBSERVATION OF CLINICAL EFFECTS

In the hope that the side effects of the stilbestrol might be reduced to a minimum, it was decided to employ smaller doses at the beginning of treatment. Whereas 2 to 3 milligrams of stilbestrol were given daily to the radium induced cases, only 0.1 to 0.3 milligram was given daily to the surgical castrates and to the physiological menopause cases. The dose was then gradually increased. With the exception of vomiting, this did not appear to make an appreciable difference in the number of undesirable side effects that were experienced. Reference to Table I shows the range of undesirable or toxic symptoms experienced by our patients as well as the percentage of improvement. In all cases the well known symptoms of hot flushes, irritability, depression, and lassitude were either eliminated or so much relieved that they could be regarded as complete recoveries. Several patients who had received previous treatment with natural estrogens in single doses of 10,000 international units volunteered the information that the stilbestrol was much more effective and gave them a more pronounced feeling of well-being. This was especially true in the radium induced cases. The type of menopause apparently did not influence the development of toxic symptoms, though considerably more stilbestrol was necessary to control the menopause symptoms in the radium cases than for the physiological and surgi-

TABLE II.—INFLUENCE ON ENDOMETRIUM AND VAGINA IN RADIUM INDUCED CASES

	Vaginal smears	Atroph. endometrium	Prolif. endometrium	Secretory endometrium	Cystic glands	None obtained
Before radium	Not taken	0	7	2	1	0
After radium	Menopausal smear	3				7
2 weeks' treatment (48 mgm.)	No response	3				7
5 weeks' treatment (114 mgm.)	5 responded	2	6			2

cal types. With the exception of 3 of the 16 patients who complained of transient nausea and 11 of the 22 patients who stated that the recurring abdominal pain persisted, all toxic symptoms disappeared as the treatment progressed. Five patients complained of intermittent cramps in the calf and thigh muscles and one patient experienced this discomfort in the muscles of the forearm. The cramps occurred chiefly during the night while the patients were lying down or during sleep, causing the patients to be awakened. It would also occur at times when arising in the morning. Fifty per cent of the radium induced cases experienced vomiting early in the course of treatment, while only 14 per cent of the physiological cases were thus affected. This can be explained by the fact that the radium treated patients received 10 to 30 times as much stilbestrol as did the physiological cases. The only reference to the drug's effect on muscle was that made by Dawson and Robson whose studies were limited to its inhibitory influence on smooth muscle. No reference to its effect on skeletal muscle was found. None of the patients who experienced the undesirable side effects considered the discomfort sufficient to discontinue the drug. It is interesting to observe that none of the postpartum patients who were given large daily doses (5 to 10 mgm.) suffered side effects.

The proliferative endometrium produced by stilbestrol apparently results in bleeding which may (1, 7) or may not (6) be regarded as a type of so called "withdrawal bleeding." All of our patients were treated without a rest period and we are therefore reluctant to consider the bleeding that ensued following treatment for variable periods of time as due to sudden deprivation. Six of the 7 cases of the physiological group bled when a total dose of 90 to 100 milligrams was administered over a period of 4 to 6 weeks. Of the radium treated patients only 3 of the 10 showed bleeding during treatment extending over a period of 4½ months. In all cases in which bleeding occurred, it began after treatment was in progress for approximately 6 weeks. We consider the fact as being of significance that bleeding ensued regardless of whether or not we employed the "deprivation method," especially since bleeding occurred in 86 per cent of the physiological cases but in only 30 per cent of the patients in whom the endometriums had been exposed to the effects of radium. Discussion of this fact will be taken up later.

LABORATORY STUDIES

The important laboratory studies concerned themselves chiefly with the vaginal smears, endometrial biopsies (Table II), and liver function tests (Table III). The potent biological effect of stilbestrol as mirrored by the vaginal smear method and the stimulation of the endometrium to proliferation has been amply observed (5, 10, 15). Our experience, with but one exception, is in agreement with those of other workers in the field. The exception observed was a distinct difference in the time of biological response in the radium cases as compared to the physiological and surgical cases. It has been generally observed that vaginal epithelial and endometrial response occur after 2 milligrams of stilbestrol has been administered daily for a period of 1 to 2 weeks. This occurred in those patients in whom no irradiation had been employed. The patients treated with radium gave no endometrial or vaginal epithelial response after 2 weeks' treatment. At the end of 5 weeks' treatment a proliferative endometrium was observed and definite vaginal smear response took place. The physiological and surgical patients showed no such tendency toward a refractory state.

STUDIES OF THE EFFECT ON LIVER

During the course of the study we were especially concerned with the effect of stil-

bestrol on the liver. In view of the moot question as to whether there is an impairment of liver function in consequence of treatment, 2 different liver function tests were performed on each of 14 patients and a single test on each of a group of 9 patients. The bromsulphthalein test (13) was done 6 to 8 weeks after treatment was initiated and again 9 weeks after treatment was started. Cognizant of the limitations of any single test as an indication of hepatic function, we supplemented this test with the hippuric acid synthesis test of Quick at intervals of between 3 and 5 months. When the dose of stilbestrol was not very large, the hippuric acid synthesis test alone was employed. The results obtained by Shorr and others who performed preliminary tests, indicate that the discrepancies observed in the hippuric acid synthesis test cannot be explained on the basis of resultant liver damage. Ten patients showed an excretion of hippuric acid of less than 3.0 grams in 4 hours. Of this number only one showed an excretion of less than 2.0 grams. The 9 others were within a range of 2.5 grams. It would be hazardous to suggest that this slight decrease can be interpreted as indicating liver damage, especially since it has been observed in some cases (15) that the hippuric acid synthesis shows improvement following administration of stilbestrol. No retention of the bromsulphthalein was observed at the end of one-half hour in any of the cases studied. As a result of our analyses it appears that the employment of stilbestrol in physiological doses gives no evidence of demonstrable liver damage in the human.

TABLE III.—LIVER FUNCTION TESTS[1]

Name	Bromsulphthalein test		Hippuric acid test Sodium benzoate	
	Date	Retention	Date	Excretion—gm.
A.O.	12-4-39 1-5-40	½ hr. 5% ½ hr. 3%	1-30-40	3.1
L.K.	12-5-39	½ hr. 0		
	1-5-40	½ hr. 0	2-23-40	2.4
N.B.	1-3-40	½ hr. 0	2-23-40	2.4
A.C.	12-4-39	½ hr. 4%		
	1-3-40	½ hr. 0	2-28-40	2.9
M.Z.	12-4-39	½ hr. 0	2-29-40	3.1
A.G.	12-5-39	½ hr. 0		
	1-5-40	½ hr. 0	3- 1-40	2.4
L.Y.	12-4-39	½ hr. 0		
	1-3-40	½ hr. 0	3-11-40	1.9
J.P.	12-5-39	½ hr. 0	3-12-40	3.01
A.C.			3-25-40	2.68
M.E.			3- 6-40	2.96
V.M.			3-26-40	3.27
M.D.	1-4-40	½ hr. 0	3-27-40	3.3
A.P.			3-28-40	4.2
E.W.			3-29-40	2.58
A.K.			3-29-40	2.77
M.P.	1-5-40	½ hr. 0	4- 3-40	3.31
S.J.	1-3-40	½ hr. 0	4- 4-40	3.17
B.McA.	12-4-39	½ hr. 0		
	1-5-40	½ hr. 0	4- 5-40	2.03
R.K.			4- 5-40	2.45
M.J.			4- 2-40	2.95
H.B.	12-5-39	½ hr. 0		
	1-4-40	½ hr. Tr.	4- 8-40	3.3
F.McK.	1-4-40	½ hr. 0	4- 9-40	2.16
M.S.	12-5-39 1-5-40	½ hr. 0 ½ hr. 0		

[1] Treatment started in each case October 30, 1939.

STUDY OF THE EFFECT ON DOG'S LIVER

The important consideration regarding the possible toxicity of diethylstilbestrol concerned itself with the effect of this drug on the liver. Aware of the limitations of present methods of evaluating liver function in the human, we turned our attention to the possible development of some anatomical (histopathological) disturbance as a result of its use. Twelve full grown dogs were employed in the study. The dogs were raised in our own laboratory and all had been on a standard ration since birth. They were divided into 3 groups of 4 each, the sexes being equally divided. The first group received 5 milligrams of stilbestrol dissolved in oil which was injected intramuscularly daily. The second group received 10 milligrams daily, and the third group served as a control. Treatment was continued for approximately one month—from November 29, 1940 to December 24, 1940. It should be observed that weight for weight, the amount of stilbestrol administered to the dogs as compared to the average human

dose was approximately 6 times as large. At the end of the injection period the dogs were anesthetized with nembutal and biopsy specimens of the liver were obtained.

Microscopic examination failed to show any difference between the livers of the treated dogs and those of the controls. These findings indicated that if a deleterious effect were present as a result of the use of diethylstilbestrol, it was not reflected microscopically in the liver.

EVALUATION OF STUDY

Response of the uterus and vaginal epithelium to treatment in the menopause patient varies with their ability to be influenced by the drug. When physiological involution has occurred, stimulation can be readily accomplished with the natural and synthesized estrogens. Radium induced menopause presents a decidedly different problem due to the type of injury resulting from its use. The radium treated patient affords an excellent means of evaluating the potency of an estrogenic substance. Stilbestrol, by mouth, was found to be effective in radium treated patients who had been refractory to previously employed parenteral preparations.

The differences in response to treatment between the physiological cases and the radium induced menopause are several. It required a longer period of preliminary treatment and the use of a dose five times as large to secure a satisfactory clinical response as well as comparable endometrial and vaginal epithelial change, as determined by biopsies and smears, in the radium treated patients as in the physiological cases. In addition to this, it is striking that only 30 per cent of the radium treated patients experienced vaginal bleeding while it occurred in 86 per cent of the physiological cases. In 2 of the 3 radium cases that had vaginal bleeding, the duration was ½ to 1½ days and was extremely scanty. In all of the physiological cases patients showed more profuse and extended periods of bleeding. An explanation of this observation lies in the effect of the radium on the uterus as reported by us (6) previously. The radium produces a marked degree of hyalinization of the stroma and portions of the myometrium, as well as tending to destroy practically all of the glandular structures. There is an associated endarteritis with a consequent interference in capillary permeability. It may be this latter condition which accounts for the diminished bleeding response that is observed in the patients treated with radium.

We limited our studies of toxicity of stilbestrol to clinical evaluation assisted by liver function tests. The knowledge that the natural occurring estrogens are metabolized in the liver centered most of the attention on that organ. Our animal studies were chiefly concerned with the possible acute toxic effects on the liver. As previously mentioned, we were unable to demonstrate any lesion in our treated dogs. Russell and co-workers recently reported their findings of chronic toxicity studies with stilbestrol. Employing rats, they found no pathological lesions in any of the organs save for an instance of cloudy swelling of the kidneys, although 5 times the average human therapeutic dose was used. When 26 times the therapeutic dose was employed, cloudy swelling of the kidneys was found to be present in 4 of 49 rats treated. Gastric hemorrhage and hemorrhage into the adrenals were observed in 1 animal. More extensive damage was reported when doses 523 times the human therapeutic dose were employed. It would apparently be the height of folly to condemn a drug because doses of such magnitude produced untoward effects. Morrell recently reviewed all of the clinical reports in this country and abroad and found no permanent toxic effects as evidenced by liver function tests, blood and urine chemistry, and histological examination of the blood and bone marrow.

CONCLUSIONS

1. Diethylstilbestrol was employed to observe the differences in response to treatment of physiological menopause cases and radium induced cases. Its influence on liver function was also studied.

2. Radium induced menopause patients require larger doses and more prolonged treatment with stilbestrol than do physiological cases.

3. Bleeding response to treatment occurred in 86 per cent of the physiological cases and in only 30 per cent of the radium induced cases.

4. The undesirable side effects of stilbestrol are transient and are not sufficient to act as a deterrent to its use.

5. Liver function tests and histological studies of dogs' livers failed to show hepatic damage after excessive doses of stilbestrol.

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A STUDY OF THE MECHANICS OF BILE FLOW

II. Responses to Intraduodenal Solutions

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In a previous paper we presented a method for simultaneous observation of the responses of the three factors we considered most important in determining the flow of bile, namely: the contractility of the gall bladder, the resistance of the sphincter of Oddi, and the tonus and motility of the duodenum. We confirmed the repeated observations of others on the independent activity of the sphincter and duodenum. In addition we reported our observations on the influence of physiological intravenous solutions on these structures (13).

Using the same experimental procedure on anesthetized dogs, we have studied the effects of various solutions introduced into the duodenum through a glass cannula which, projecting beyond the recording balloon, was tied around the cannula. All solutions were retained within the duodenum for a uniform length of time (2 minutes).

Intraduodenal instillation of 20 cubic centimeters of fresh gastric juice procured from dogs with Pavlov pouches of 1.12 to 1.14 1/10 normal hydrochloric acid concentration was observed on 13 occasions in 10 dogs. In every instance not complicated by previous medication, an immediate marked elevation in sphincteric pressure coincident with a marked duodenal spasm was elicited; both persisted for a considerable length of time after the juice had been permitted to drain out of the duodenum (Fig. 1). The gall bladder usually showed no characteristic response but in 2 instances there was a slightly increased tonus associated with an increase in motility. Blood pressure frequently revealed a 10 to 15 millimeter drop immediately following the injection.

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A preliminary report was read at the meetings of the American Physiological Society, April 19, 1941, Chicago.

Dr. Kozoll, Bernard Portis Research Fellow in Surgery.

Injection of similar amounts of tenth normal hydrochloric acid into the duodenum was followed by identical responses, although our gastric juice was slightly more acidic. Oddi, in his original work, stated that dilute hydrochloric acid caused a spasm of the sphincter, but later work has been contradictory (5, 8, 9, 18).

Antispasmodics, such as atropine and trasentin, did not prevent the effect of gastric juice (refer to previous paper, Fig. 4). No significant changes in gall-bladder tone or motility were observed following intraduodenal administration of hydrochloric acid or gastric juice. This is contrary to the experience of others (9, 18) but agrees with that of Bainbridge and Dale.

Twenty cubic centimeters of 1/20 normal sodium hydroxide instilled into the duodenum of 3 dogs, produced marked responses in each case. These were characterized by sphincteric spasm producing a prolonged rise in intraductal pressure (100 mm. and above). The duodenum responded with a marked increase in tonus and motility, which did not always parallel the change of the sphincter resistance. The gall bladder showed no characteristic response, the blood pressure was unaffected, but this solution frequently produced hyperpnea (Fig. 3). These findings are consistent with the work of others (1, 5, 9). It is to be noted that sodium hydroxide produces much more marked and prolonged spasm of the duodenum and the sphincter than does hydrochloric acid of the same strength.

Injection of 5 to 10 cubic centimeters of a 1:1000 solution of peppermint water into the duodenum produced marked responses in practically all of 5 animals in which it was used. This agent produced a sphincteric spasm amounting to as much as 100 millimeter increase in intraductal pressure which frequently preceded and was out of proportion

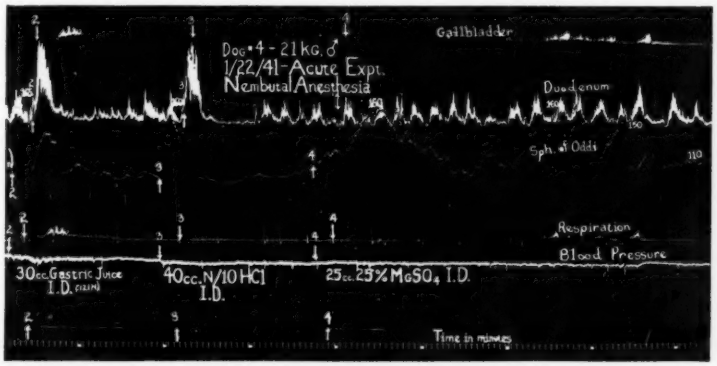

Fig. 1. At *2*, gastric juice intraduodenally, produced a concurrent spasm of sphincter and duodenum, but a recurrent sphincter spasm was not associated with further duodenal response. At *3*, 1/10 normal hydrochloric acid had a similar effect. At *4*, magnesium sulfate, intraduodenally, produced marked sphincter spasm with little effect on duodenal tone.

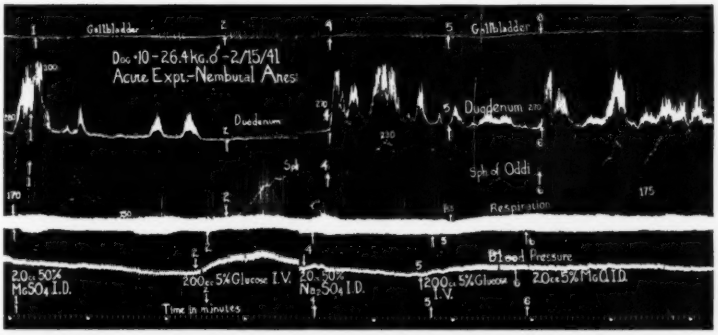

Fig. 2. At *1*, magnesium sulfate, intraduodenally, produced an initial marked spasm of sphincter (130 mm. increase in pressure) coincident with duodenal spasm. Subsequently there was a lowering of sphincter tone below the control level, whereas duodenal tone and motility was restored to normal. At *2*, glucose, intravenously, produced a 50 millimeter gradual rise in sphincter pressure, while depressing duodenal activity. At *4*, diosodic sulfate, intraduodenally, produced similar effects as did magnesium sulfate. At *5*, isotonic glucose, intravenously, again raised sphincter pressure while depressing duodenum. At *6*, magnesium oxide intraduodenally, produced marked recurrent spasms of sphincter which were coincident initially with duodenal spasms, but later were independent of it.

to a duodenal increase in tonus and motility. This effect is quite surprising in view of the fact that peppermint water is a time honored carminative. There was no effect on the gall bladder.

Twenty cubic centimeters of fresh dog's gall-bladder bile, introduced into the duodenum, produced no effect other than the transitory mechanical effect due to distention of the duodenum (Fig. 3). As control, 20 cubic centimeters of normal saline was given, with similar negative results.

Twenty cubic centimeters of 25 per cent peptone solution, injected into the duodenum caused a moderate increase in sphincteric resistance and duodenal activity, which was of relatively short duration, and no gall-bladder response (Fig. 3). Peptone has been described as a cholagogue secondary in effectiveness to egg yolk (1, 18).

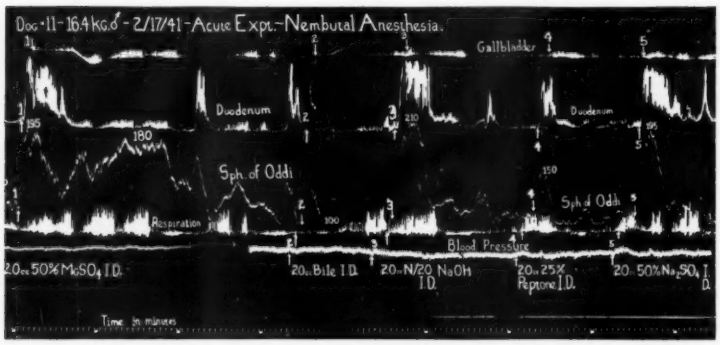

Fig. 3. At *1*, magnesium sulfate intraduodenally, produced an initial 90 millimeter rise in sphincter pressure coincident with duodenal spasm. Subsequently a prolonged rise in sphincter pressure occurred, while duodenal tone and motility were low. Note relaxation in tone of gall bladder. At *2*, intraduodenal injection of bile had only a mechanical effect on the duodenum. At *3*, 1/20 normal sodium hydroxide, intraduodenally, produced simultaneous spasm of sphincter and duodenum with minor subsequent responses. At *4*, peptone solution, intraduodenally, produced a moderate coincident spasm of duodenum and sphincter. At *5*, diosodic sulfate had similar effects as 1/20 normal sodium hydroxide.

Twenty cubic centimeters of a 25 to 50 per cent solution of magnesium sulfate was injected into the duodenum, and produced variable responses in 6 dogs in which it was used. The literature on magnesium sulfate has been completely reviewed by Ivy, and our results reflect similar variabilities in the response to this drug. The drug is known to have an effect in the dog which is quite different from that which is supposed to occur in the human. In all animals this agent invariably produced an initial marked increase in sphincteric tone and duodenal activity (Figs. 1, 2, and 3). After this initial response, in some animals there is a decrease in sphincteric and duodenal tone below that of what it was prior to injection (Fig. 2), whereas in others the sphincteric tone rises again in spite of the fact that the duodenum remains quiescent (Fig. 2 and 3). Particular attention is called to the occurrence of waves of spastic contraction of the sphincter of Oddi without similar response on the part of the duodenum. No effect was noted on the gall bladder except in one animal in which lowering of gall-bladder tone occurred parallel to the rise of intraductal pressure and lowering of duodenal tone (Fig. 3). This is the converse of the reciprocal effects on the gall bladder and sphincter attributed to magnesium sulfate by a number of observers (3, 10, 14, 15, 16, 17). Auster and Crohn quote work that proves that magnesium sulfate contracts rather than relaxes smooth muscle and that the local effect upon the duodenal obscures the effect on the sphincter. Doubt as to the consistent reciprocal effect of magnesium sulfate has been expressed (1, 5, 7, 19). Ivy did not see contraction of gall bladder of dogs after intraduodenal instillation of magnesium sulfate (10).

Injection of 20 cubic centimeters of 50 per cent sodium sulfate into the duodenum of 4 dogs (Figs. 2 and 3) produced a consistent spasm of the sphincter and the duodenum, more prolonged than the initial response with magnesium sulfate, with a slow return to normal activity. Sodium and magnesium sulfate have been recommended as cholagogues (1, 11), but if our results can be applied to man, they would cast doubt upon the accepted mechanism of their action.

Twenty cubic centimeters of 5 per cent magnesium oxide injected into the duodenum of 5 dogs produced marked and prolonged increase in the resistance of the sphincter and in duodenal peristalsis. The rise in sphincteric resistance frequently was out of proportion to changes in duodenal tone (Fig. 2). The gall bladder showed no response.

Olive oil, 32 per cent cream, egg yolk, and a mixture of egg yolk and cream when intro-

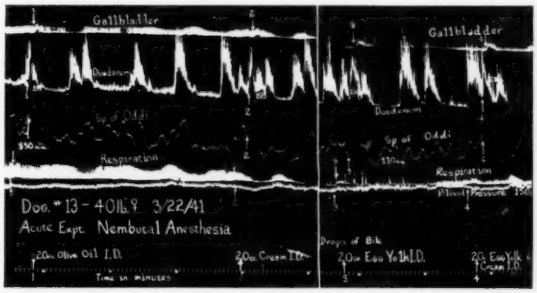

Fig. 4. At *1*, the intraduodenal instillation of olive oil produced a contraction of the gall bladder and an initial coincident transitory spasm of the sphincter and duodenum; subsequently, the sphincter resistance fell to a level lower than what it was prior to injection. At *2*, 32 per cent cream instilled into the duodenum; at *3*, egg yolk; and at *4*, a mixture of 32 per cent cream and egg yolk; had an almost identical effect, except that the latter two preparations produced more effective contractions of the gall bladder.

duced into the duodenum produced similar effects: an immediate contraction of the gall bladder associated with a simultaneous increase in sphincter and duodenal tone of 3 to 4 minutes' duration (Fig. 4). Following this, sphincter tone falls to a level below that prior to injection for a similar interval and subsequently rises to its control level. We found a mixture of egg yolk and cream to produce the greatest contraction of the gall bladder of all agents injected into the duodenum. This response was not influenced by previous antispasmodic medication with atropine or trasentin (diphenylacetyldiethylaminoethanol hydrochloride).

In summary of our results with agents injected into the duodenum, acid substances such as gastric juice and 1/10 normal hydrochloric acid produced relatively short increases in resistance to bile flow. Relatively neutral media, such as magnesium sulfate and sodium sulfate, increased the tone of the sphincter out of proportion to their effects on the duodenum. Alkaline media such as sodium hydroxide and magnesium oxide, produced marked simultaneous responses in the sphincter and duodenum which would appear to oppose the flow of bile the longest. It is to be remembered that it is an increase in duodenal tone, and not so much of motility, that opposed the flow of bile. None of these agents introduced into the duodenum showed a consistently uniform effect on the gall bladder. The latter may have been due to the washing-out effect of the constant perfusion with 0.9 per cent sodium chloride solution, by which substances like cholecystokinin may have been eliminated. This is not probable, however, because a number of tests were carried out in the beginning of experiments when little washing-out could have occurred.

ANALYSIS OF STUDY

The entrance of gastric juice or rather of the hydrochloric acid of the gastric juice, has been held responsible chiefly for the liberation of cholecystokinin in the duodenum and jejunum. Therefore small quantities of gastric juice or dilute hydrochloric acid were perfused through the duodenum. Contraction and rise of tone occurred simultaneously in both sphincter and duodenum, but the gall bladder was hardly affected in most experiments. We know from experience with pancreatic secretion following introduction of hydrochloric acid into the duodenum that the secretin mechanism may be fatigued. It is possible, therefore, that the absence of gall-bladder contraction following injection of gastric juice into the duodenum may be explained on a similar basis, namely that the constant perfusion of the duodenal segment by the saline solution may have washed out preformed cholecystokinin. This is questionable, how-

ever, because in the numerous experiments performed, a number were done after a short perfusion only of the duodenum, and yet with the same negative results on the gall bladder. Furthermore, various fats were effective when introduced in a like manner.

If gastric juice or hydrochloric acid produce spasm of the sphincter and duodenum this may explain why bicarbonate or other antacids are beneficial in certain cases of disease of gall bladder and extrabiliary system. The effects of gastric juice and of hydrochloric acid were unaffected by small intravenous doses of atropine or trasentin.

The effect of alkaline solutions administered intraduodenally deserves discussion, because some of the alkalies taken by mouth will appear in the duodenum as sodium hydroxide, and because magnesium oxide is used largely in the treatment of upper abdominal distress. Figures 2 and 3 illustrate that administration of magnesium oxide and sodium hydroxide was followed by marked subtetanic contraction of duodenum and sphincter, the latter being more prolonged than the former (Fig. 3). Although the degree of dilution in the stomach and gastric emptying time in the human after ingestion of alkalies may modify such a response considerably, the above observations should be kept in mind.

The ability of egg yolk and cream to act as gall-bladder evacuants has been amply described by Boyden, but its effect on the sphincter has not been emphasized. The initial phase of spastic contraction of sphincter and duodenum might well account for the "two minute pause" described by Boyden (4) as elapsing between the entrance of this material into the duodenum and the evacuation of the gall bladder.

SUMMARY

1. The introduction of various agents into the duodenum was associated with immediate spasms of the sphincter of Oddi and of the duodenum of varying duration, the more alkaline media (such as sodium hydroxide and magnesium oxide) appearing to oppose the flow of bile the longest.

2. Magnesium or sodium sulfate had a variable effect on the sphincter of Oddi and duodenum of the dog, with no consistent effect on the gall bladder.

3. Fats introduced into the duodenum effectively contract the gall bladder; the most effective preparation was a mixture of egg yolk and cream.

4. The initial spasm of the sphincter of Oddi and duodenum produced by intraduodenal instillation of fats is suggested as a possible explanation of the "two-minute pause" described by Boyden as the initial phase in the evacuation of the gall bladder.

5. The independent activity of the sphincter and duodenum during various phases of the response to magnesium sulfate is offered as further evidence that they are independent physiological mechanisms, although frequently similar in their reaction.

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A NEW METHOD OF REPAIR FOR INDIRECT INGUINAL HERNIA CONSIDERED IN REFERENCE TO PARIETAL ANATOMY

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THE problem of repairing inguinal hernia remains unsolved despite the memorable contributions of Bassini and Halsted. The numerous modifications of the operation introduced by those pioneer surgeons, indicate that, although both methods have shown the way to far better results than were obtained earlier, neither has proved to be a completely satisfactory solution. Prior to the introduction of these techniques, recurrences were so common that most physicians despaired of curing the condition; one reads of recurrence rates in a single series reaching as high as 90 per cent. It is little wonder, then, that a method which enabled surgeons to reduce this high incidence of failures to a figure around 10 per cent should be widely adopted and accepted by most as a satisfactory operation.

A survey of the literature convinces one of the lack of agreement among authorities as to the frequency of recurrence with present day surgical methods. This may be attributed to a number of factors, chief among which is the difficulty of accurate follow-up examinations over a sufficient period of time in any large series of cases. Zimmerman warns against the fallacy of accepting verbal or written communications from patients as reliable information; he maintains that only by careful examinations, covering a period of several years, is the surgeon justified in drawing conclusions as to results. Few series of cases have been reported in which such re-examinations have been carried out for more than 75 per cent of the patients in the series. Moreover, it is probable that the rate of recurrence is much higher among the cases not followed, for many of those who suffer a return of the original trouble are quite likely to go elsewhere for further advice and treatment. Most hernia sufferers have a friend who has experienced a recurrence following an attempted surgical repair and all have been warned concerning this danger; it is only natural that many of those who suffer a recurrence should abandon hope of securing permanent relief through surgery, and consult the truss-maker for further help. Aversion to the truss is the factor usually responsible for the return of the patient to the doctor —probably a new doctor. Of the last 4 cases of recurrent inguinal hernia in which patients were operated upon by one of the authors (WKJ) 3 had been patients of other surgeons who knew nothing of the secondary rupture. Although it is well known that a careful repair is seldom followed by recurrence under 6 months, the majority of statistical reports include patients recently operated upon as well as cases which have been observed for longer periods. Inasmuch as most surgeons today employ the Bassini technique, or one of its numerous modifications, it is difficult to reconcile the widely divergent results reported by men whose experience in this field should establish them as authorities. It would seem, therefore, that the higher figures for recurrence are most reliable (Table I). This contention is further substantiated by the abundant literature on the subject, as well as by the numerous operative procedures recommended for its correction.

A new principle in the treatment of femoral hernia was recently proposed by Professor Henry, of Cairo, Egypt, who described a procedure in which the femoral ring was exposed by a retroperitoneal approach through a low midline incision. The advantages which such an operation provide are: (1) direct exposure of the opening through which the hernial sac

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TABLE I.—INCIDENCE OF RECURRENCE REPORTED WITH USUAL OPERATIONS FOR HERNIA*

Author	Cases	Followed	Indirect per cent	Direct per cent	Recurrent per cent	Total per cent	Remarks
Abegg	214					3.09	Examination
Adler	103	3 yrs.				0.97	Examination
Andreus and Bissell	48			27			Examination
Barth	494					1.80	Questionnaire
Bessin	242	4 yrs.				4.13	Questionnaire
Birkenfeld	166	1½ yrs.				15.0	Examination
Block	20,199 6,024	Collective statistics				3–3.5 4.9	Total series Examination
Catterina	20,000					1–2	No follow-up
Druener	408					1.4	Follow-up ?
Fallis	800 200	3–10 yrs. 1 yr. or more	7.4	11.6	13	8.5	Examination Examination
Glenn and McBride	305	6–24 mos.	2.37	6.21	30		Examination
Grace and Johnson	784	1–10 yrs.	21.1	32.9	34		Patients all over 50 yrs. old
Groth	683	3–11 yrs.	11.2	25.3			Questionnaire
Huston	1,500					0.8	No follow-up
Jason	50	1 yr.			13		Examination
Lidermann	408	1–19 yrs.	3.2	4.1		3.3	Examination
Niessen and Potts	88	3–27 mos.				6.8	Examination
Ostfeld	239	2 yrs. up	4.3	20.0		5.4	2/3 examined
Page	206	5–9 yrs.	20.2	25.0			Examination
Parsons	244 458	Catgut, Silk: 1 yr. and up	9.8 2.16	13.6 4.49	23 7.1		Examination Examination
Schaer	1,928	1½–11½ yrs.	2.5	6.2	13.6	3.5	Examination
Spangaro	394					4.5	Examination
Stanton	587	1–29 yrs.				9.8	Follow-up ?
Wachsmith and Everken	197					6.3	Examination

*Zimmerman, L. M., Internat. Abstract Surg., 1939, 68.

protrudes, (2) guarantee of high ligation of the sac, and (3) avoidance of scar tissue in the inguinal sector of the abdominal wall. In the carrying out of this procedure it was observed that excellent exposure of the abdominal inguinal hiatus was possible by a slight additional retraction of the rectus muscle laterally. This observation suggested that a procedure, similar to the one proposed by Henry, but adapted to the requirements of indirect inguinal hernia, might possess fundamentally the same advantages.

The standard accounts, to which the anatomist and surgeon have accustomed themselves, describe the inguinal canal as an indefinite "space" of oblique course whose parietal constituents are strong representations of the layers which make up the abdominal wall. In these accounts the subcutaneous orifice of the canal is loosely termed a "ring," and the degree to which muscle fascicles of the internal oblique are drawn outward through this orifice is often exaggerated; the fascial contribution from the transversus abdominis is inadequately described, and the adipose continuation of the preperitoneal connective tissue is usually disregarded. In almost eve instance inguinal anatomy is presented as if always conformed to a definite pattern. In view of these facts, it was considered desirable to re-examine the inguinal strata carefully—and, by dissection, in the order in which they would be encountered by a hernia. This posterior approach proved to be particularly applicable to the surgical method presented, since the latter technique affects primarily the deeper abdominal layers

I. ANATOMY

Serial dissections were carried out in an unusually favorable, muscular, white male,[1] and an accurate drawing was prepared of each of the several stages in the dissection. In the descriptions of the important anatomical features thus recorded, the innermost stratum will be considered first, the external oblique last, since this is the succession in which a hernial mass encounters the series of parietal laminae.

a. Peritoneum. The peritoneum of the left side of the specimen illustrated is of the normal adult disposition; elevated in low folds over the middle and the lateral umbilical ligaments (Fig. 1).[2] On the right side, in addition to being draped over subperitoneal ligaments, the peritoneum is carried outward as a serous hernial sac which is the persistent processus vaginalis (Fig. 1). Through the serous layer are visible the linea semicircularis, rectus muscle, inferior epigastric vessels and the line of the inguinal ligament—the muscle, artery, and ligament bounding the triangular space (of Hesselbach) to the lateral aspect of which the hernia protrudes.

b. Preperitoneal tissue. Through much of the inguinal area the layer of preperitoneal connective tissue is of cobweb-like texture, almost devoid of fat (Fig. 1, left half). Within it are imbedded the several umbilical ligaments, and the inferior epigastric vessels. The preperitoneal layer, along the pelvic wall, is considerable in amount; traced outward from the abdominal inguinal "ring" it is lost in the proximal part of the inguinal canal. In many specimens, however, this funicular continuation of the retroperitoneal tissue is appreciable in amount, forming a lobulate collection deep to the internal spermatic fascia; in bulk it may then equal the combined mass of the other constituents of the cord. It would, assumedly, constitute a resilient tissue easily compressible under pressure of an advancing indirect inguinal hernia.

c. Transversus abdominis muscle. The transversus abdominis muscle is almost universally described as forming a superior boundary for the inguinal canal, its fascia a posterior wall; the fascial layer which is invariably described is the internal investing, or transversalis, fascia; the thinner external layer is disregarded.

In the specimen herein illustrated, the transversus abdominis, as usual, becomes aponeurotic and fascial as the inguinal canal is approached (Figs. 2 and 3; cf. Fig. 5, McVay and Anson, 1940); the lower part of the transversus (i.e., the area at the inguinofemoral border) is totally fascial, no aponeurotic fibers being seen in the part prolonged upon the cord. The layer is so thin that the yellow fat preperitoneal is plainly visible through it; in spite of the fascial character, it is removable, as a whole layer, from the fat.

In the standard accounts the transversalis fascia—which is the internal one of the two investing fascial layers of the transversus—is treated as if it were the sole contributor to the internal spermatic fascia. Yet the thinner external layer of investing fascia contributes part of the substance of the latter, although to lesser degree; the external investing layer is traditionally disregarded, assumedly because, in the course of regular dissection, it is removed to expose the muscular portion of the transversus.

In the current specimen the transversalis fascia is a strong and definite layer on the inner aspect of the transversus abdominis. On the right side, carried into the inguinal canal, it forms a fascial diverticulum situated just lateral to the inferior epigastric vessels (Fig. 2, right half); this is, of course, the tubular pro-

[1] The specimens are adult white cadavers of average height and weight.

[2] In addition to the descriptions presented in the legends, the following comments on the dissections may be of interest to the reader: In Figure 1, for service in topography, the pelvic and perineal structures are included in the drawing; in the pelvis, urinary bladder, prostate (hypertrophic; sectioned in the plane of the prostatic urethra), pelvic diaphragm, obturator internus muscle, alae, ischiopubic rami, acetabula, etc.; in the perineum, urogenital diaphragm (superior to which the dorsal veins of the penis enter the pelvis), erectile bodies (with muscles) at the level of the bulb of the urethra. The most inferiorly placed layer is the fascia of Colles (deep layer of the perineal superficial fascia). Structures situated external to the pelvis have been removed. The outline of the margin of the rectus sheath, the boundaries of Hesselbach's triangle are seen. In Figure 2 the urinary bladder has been drawn backward to expose the pubic part of the bony pelvis, the obturate vessels and the pubic branches of the obturator arteries. The pelvic diaphragm is included in the area illustrated, but not the struc s inferior thereto. In Figure 3, the bladder and prostate (with large exiform veins) have been excised to show the important bony structur n the anterior part of the pelvis. Further, in removal of the obturator a superior diaphragmatic fasciae, the pubic portions of the levator ani and obturator internus have been exposed on both sides; the pubic symphysis, inferior pubic rami and pubic arcuate ligament, are shown; also the dorsal penile vein in relation to the arcuate ligament and the transverse pelvic ligament. The bulb of the urethra (marking the level of the superficial perineal compartment) remains as an additional landmark. Vessels have been removed, except for the following: distal parts of the external iliac arteries and veins; upper reaches of the inferior epigastric arteries with branches, laterally, to the muscles of the inguinal wall; dorsal vein of the penis (at the pubic arcuate ligament); arterial plexus (left side) from the pubic branch of the obturator artery. In Figure 5 the urogenital and pelvic structures are also removed, in order to demonstrate fundamental bony relations: symphysis and rami (superior and inferior), now freed of muscular and aponeurotic attachments.

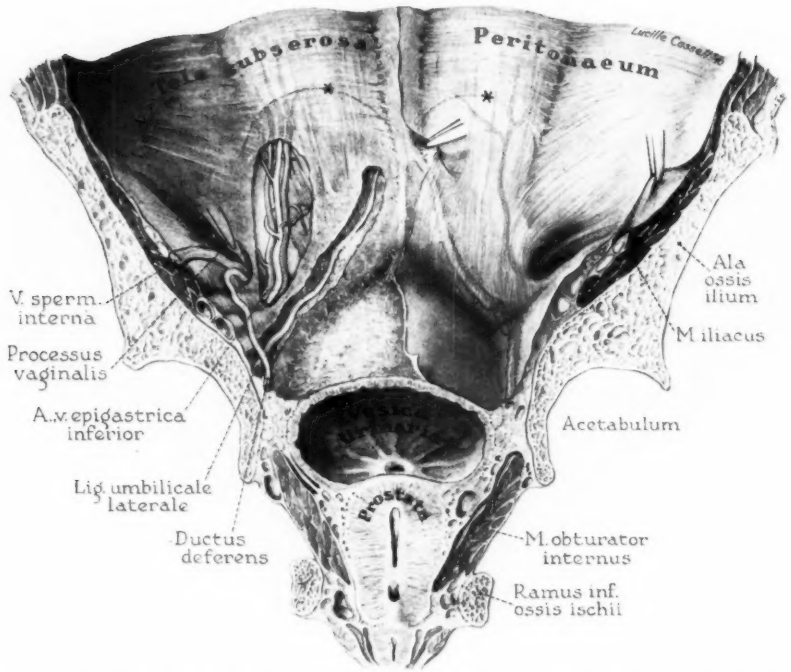

Fig. 1. Internal aspect of the anterior abdominal wall: peritoneum and preperitoneal connective tissue (see also footnote). The pelvis has been coronally sectioned, the line of section passing through the iliac fossae, acetabula, and ischial rami. On the right (hernial) side the peritoneum is intact; on the left (normal) side it has been removed to expose the preperitoneal layer in which lie the umbilical ligaments. The preperitoneal layer has been removed only along the course of the inferior epigastric artery. Through it (right side) are visible, rectus muscle, inferior epigastric artery, linea semicircularis. The iliac fascia of the greater pelvis has been freed from muscle as has, likewise, the thin preperitoneal layer from the muscle fascia. The peritoneum remains on the right half of the superior surface of the urinary bladder; on the left the combined preperitoneal and endopelvic fascial layers are exposed.

longation of internal spermatic fascia dilated by hernial protrusion. Medially it is carried upward in the midline as a thickened, pointed process, the adminiculum. Where the transversalis fascia reaches the lateral margin of the rectus muscle it splits to form the rectus fascia (Fig. 3). It is easily dissectable from the muscle in the area below the semicircular line; however, it cannot be easily separated, as a distinct layer, from the aponeurosis of the transversus either along the lateral border of the rectus abdominis or upon the latter muscle itself above the level of the semicircular line.

d. Internal oblique muscle. The lower inguinal part of the internal oblique—with the subjacent, and corresponding, portion of the transversus abdominis—arises from the iliopsoas fascial tube, not from the inguinal ligament (McVay and Anson, 1940, Figs. 1 and 3). The attachment to the inguinal ligament is accomplished only through the fasciae which cover the opposed surfaces of the muscle and ligament. The muscle fibers usually descend, closely grouped, on the posterolateral aspect of the spermatic cord. It is exceptional to find more than a fascial remnant of this stratum ascending on the medial side of the cord to a pubic insertion.[3]

[3]The statement (in Morris) that the superficial muscle fasciae of the external oblique and internal oblique are continued into the thin cremasteric muscle, etc., is entirely erroneous; nor is it derived from the aponeurosis. Within the general layer of external investing fascia the tendinous intercrural fibers are merely local specializations; the fascial layer is prolonged, the fibers happening to be situated just lateral to the part of the fascia which is displaced; the fibers are not aponeurotic.

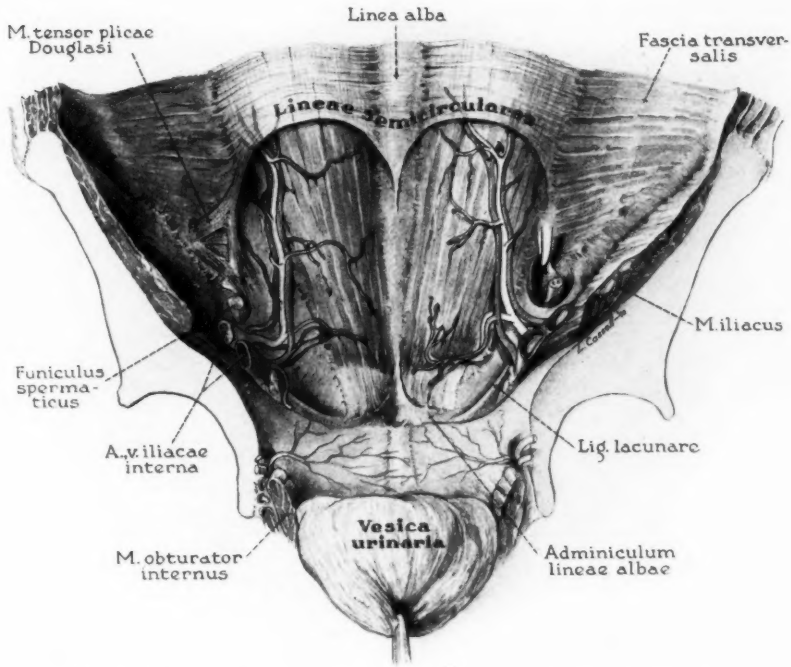

Fig. 2. Abdominal wall from within: transversalis fascia. The preperitoneal tissue has been removed, the transversalis fascia and iliopsoas fascia exposed.

On the right side the layer is displaced from its natural site, lengthened to invest the protrusion (Fig. 4); as if incapable of excessive prolongation, the muscular fascicles are carried but a fraction of the way, the more resilient fascia through the full extent of the testicular descent. Just as the investing fascial layers of the external aponeurosis are protruded between crura, so the comparable layers of the internal muscle are stretched between adjacent muscle fascicles. The cremasteric fascia is, then, a definite sheet, not merely an areolar filling—so definite that, although muscle fibers are commonly sparse in the cremasteric fascia, it remains as a layer so readily separable that it is demonstrated in virtually all student dissections.

e. External oblique muscle. It should now be clear that in a consideration of the three abdominal layers, a sharp distinction must be drawn between the musculo-aponeurotic and the fascial elements; failure to do so accounts for the ambiguity of some current descriptions and for the incorrectness of others. Although muscular fascicles and aponeurotic bands may terminate rather abruptly to form free margins, the associated fascial layers continue uninterrupted to bone, aponeurosis, or other fascia; when drawn away from its original site, each stratum maintains its continuity with the undisplaced portion of the same layer. Because these simple concepts are not carefully regarded, the true nature of the subcutaneous inguinal ring is not made clear in some textbook descriptions.

The interval in the aponeurosis is triangular in outline; any annular character is due to the presence of fascial tissue. The cleft, in the authors' experience, is elongate, not uncommonly extending superolaterally as far as the muscle belly or even to the anterior superior iliac spine.

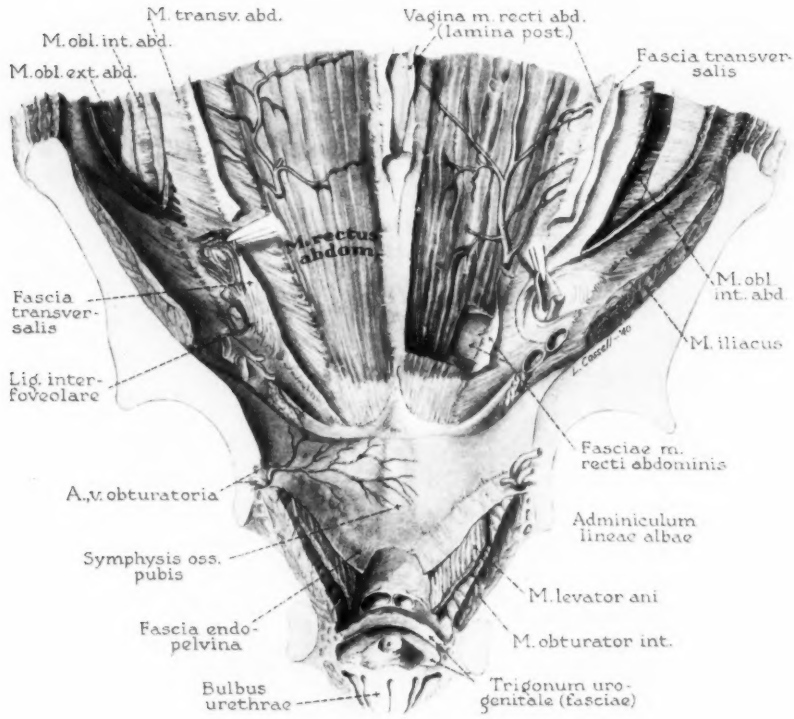

Fig. 3. Abdominal wall, continued: transversus abdominis muscle and aponeurosis, and the layer's contribution to the spermatic cord. The transversalis fascia has been removed from both sides. On the right side, additionally, the transversus abdominis muscle has been cut away in a V-shaped area, exposing the internal oblique. At the lateral border of the right rectus muscle a window has been cut to expose the layer of rectus fascia (derived from the transversalis) which passes in front of the muscle. The aponeurosis of the transversus (medially) is intact, and is distinguishable from the layers of rectus fascia. The transversus has been similarly cut on the left side; additionally the internal oblique is cut away in a V-shaped piece near the anterior superior spine, showing the muscular part of the external oblique, and the investing fascial layers on the abdominal aspect of each of the muscles. The iliopsoas muscles have been removed from the iliac fossae except near the inguinal ligament. The transected external iliac vessels rest upon the iliopsoas of each side.

The superior crural and the neighboring fibers spread out evenly upon a flat surface of pubic attachment; there is no evidence of marginal thickening, or of local clumping; the front of the pubis, inferior to the level of the crest, is wholly covered by aponeurosis (Fig. 1, Anson and Ashley, 1941). All descriptions emphasize the concept of crural boundary of a triangular intercolumnar space; but, when the superior crus is cut and turned aside, the attachments of the crura are shown to be surprisingly far apart, the external orifice broad when the horizontal distance is considered (Fig. 2, Anson and Ashley, 1941). The superior crus attaches along a line on the front of the pubic body, several centimeters inferior to the level of the crest (when the oblique distance between crura is 1.0 cm. for example, the transverse may be as great as 3.0 cm.). The orifice therefore extends almost to the symphysis. When elevated by a herniating mass, the superior crus would be merely a constricting band on the anterosuperior aspect of triangular osseoaponeurotic foramen.

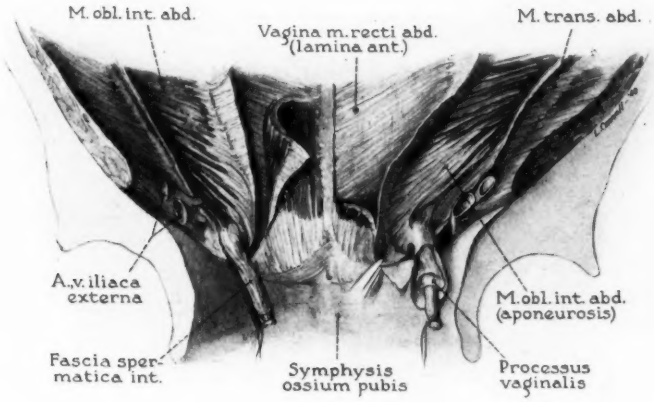

Fig. 4. Abdominal wall, continued: internal oblique layer. On the right (hernial) side the transversalis fascia and transversus abdominis remain at the marginal attachments only, and upon the sac; the internal oblique, is, therefore, almost entirely exposed. For purposes of comparison, on the left side the exposure is similar.

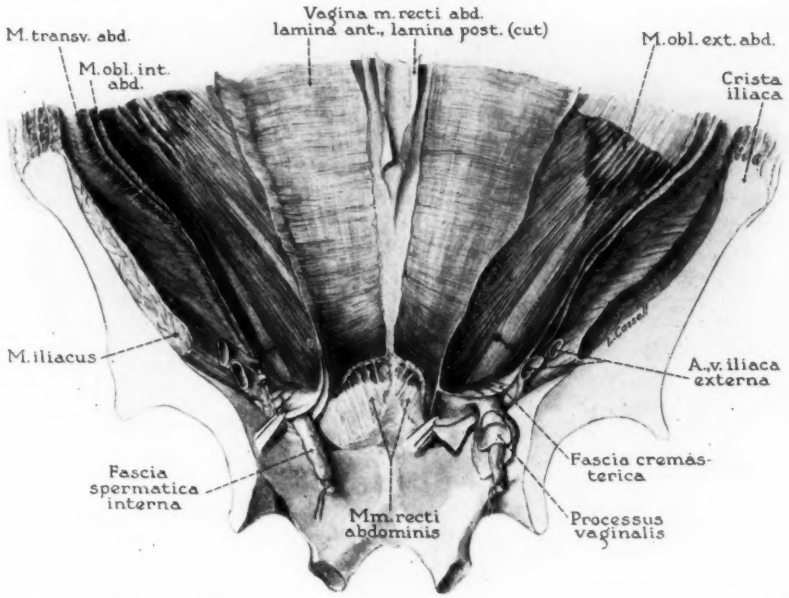

Fig. 5. Abdominal wall from within, concluded: external oblique muscle and aponeurosis (freed of internal investing fascia except in a small area on the right side). The internal oblique has been almost entirely removed; the rectus and pyramidalis muscles have been excised to show the anterior layer of the rectus sheath; the transversalis and rectus fascia have been removed except at the attachment along the pubic crest. The internal spermatic fascia is present as a constituent of the hernial sac. The transversus abdominis muscle appears merely as a narrow strip along its inferior attachment. The funicular part of the internal oblique is chiefly fascial. The triangular cleft in the external oblique aponeurosis of each side is demonstrated (margins indicated by arrows), as is the thin fascial layer which crosses the space in the aponeurosis.

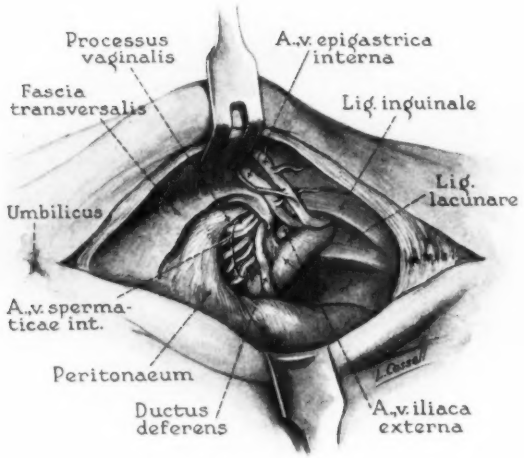

Fig. 6. Exposure, in an anatomical specimen, of the structures at the abdominal inguinal ring; through a median incision (umbilicus to symphysis) simulating that proposed, surgically, in the current article. The margins of the incision have been retracted, the peritoneum has been displaced by blunt dissection. By this procedure the ring is exposed retroperitoneally; also shown are the following structures which are associated with the abdominal ring: external iliac vessels as they near the femoral canal; the vaginal process of the peritoneum, the spermatic vessels and the ductus deferens as they converge to form the cord; the inferior epigastric vessels as they lie to the medial side of the abdominal inguinal ring.

The inherent weakness in the area of the subcutaneous inguinal "ring" is not due to a lack of intercrural fibers medially. Strong fibers of this type are not placed with such restricted and definite distribution, usually being lodged in the outer layer of investing fascia of the external oblique aponeurosis above and to the medial side of the aponeurotic cleft (McVay and Anson, 1940). It is the general fascia, not these special fibers, which forms the funicular covering. The intercrural fibers are quite subsidiary, and are not carried downward on the cord.

The fascia at the aponeurotic hiatus is not merely external investing (innominate) fascia; it is bilaminar in origin, consisting of an internal investing layer as well, the two fused back-to-back. Thus fused as an intercrural or intercolumnar fascia, the single (conjoined) layer is prolonged upon the cord as the external spermatic fascia. As already stated, the separately definable intercrural fibers do not extend in their distribution to the medial area of the aponeurotic cleft and, consequently, do not contribute to the substance of the funicular tube; in fact, the intercolumnar fascia is thinnest near the site of prolongation. This means that there is regularly an area of weakness between the aponeurotic crura; in herniating, the mass merely separates further the crural boundaries of a triangular area whose covering tissue is fascial only (Fig. 5).[1] Having widened the thin funicular "sac" formed by external spermatic fascia, the hernial mass pushes outward through the intercrural space; the strong crura then tend to return to normal position, with the result that the external fascial sac, the contained saccular coverings derived from the successively deeper abdominal strata, and the true hernial contents, are clamped between columnar (crural) "ligaments" (see Figs. 1 and 2, Ashley and Anson, 1941). Therefore, not only does the fascial part of the external oblique constitute an inefficient barrier against hernial protrusion, but the marginal aponeurotic bands are readily displaced to permit of egress.

II. SURGERY

These anatomic studies afforded a better understanding of the structural relations as encountered in a retroperitoneal approach to the inguinal canal and convinced us that in principle any operation which effects a high ligation and removal of the hernial sac, closure of the so called abdominal inguinal "ring" and avoidance of any trauma to the transversalis fascia, or other structures about the inguinal canal, is fundamentally sound. Accordingly, a technique was planned in which the low mid-

[1] It should be added as a matter of record that the iliopsoas fascia meets and fuses with the transversalis except where the femoral vessels intervene. The transversus arises from the iliopsoas fascia not from the upturned border of the inguinal ligament. An effective barricade against lateral herniation is thus formed (McVay and Anson, 1940).

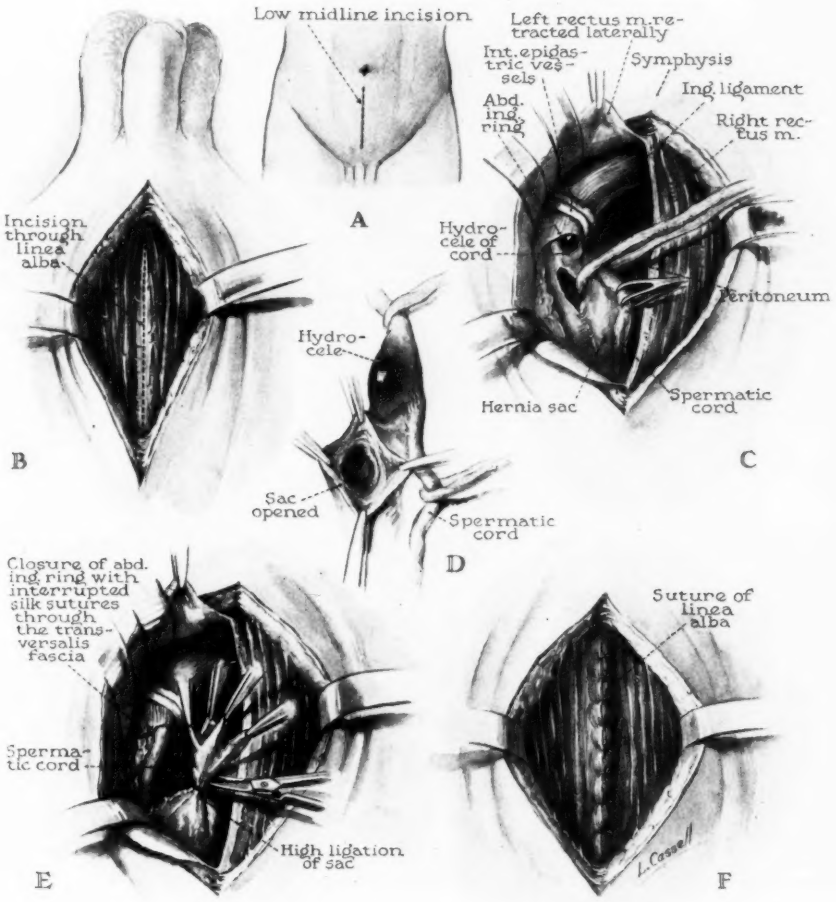

Fig. 7. Technique for the repair of indirect inguinal hernia through low midline incision. *A*, Skin incision; *B*, incision through the fascia adjoining recti muscles; *C*, Separation of the left rectus muscle from the peritoneum by blunt dissection—the muscle is retracted laterally to expose the inguinal ligament, the structures of the spermatic cord and the abdominal inguinal hiatus. A tape encircles the cord to aid in identifying and separating the hernia sac (small hydrocele of the cord is present). *D*, The sac, having been dissected free from the spermatic cord, is now opened; *E*, high ligation of the sac is completed and the sac is excised; 2 interrupted silk sutures have approximated the transversalis fascia in order to reduce the size of the abdominal inguinal ring (the lower leaf of transversalis fascia is obscured by adipose tissue); *F*, The fascia is closed with interrupted silk sutures.

line incision described by Henry is used (Fig. 7, a); this is carried down through the rectus fascia at the linea alba (Fig. 7, b) to the peritoneum, the latter being separated from the posterior surface of the rectus muscle by blunt dissection. The urinary bladder may appear in the lower field, in which case it is carefully pushed away from the overlying structures. The lateral dissection is easily accomplished because of the loose areolar tissue between the peritoneum and the rectus muscle which separates readily. The dissection is carried as far

TABLE II.—INDIRECT INGUINAL HERNIA OPERATED UPON BY MIDLINE RETROPERITONEAL APPROACH

Patient	Age	Date of operation	Followed	Recurrence	Remarks
1. V.H.	47	3-27-40	1 yr.	0	
2. C.H.	45	2-16-40	1 yr.	0	Scrotal hernia
3. D.P.	62	2-24-40	1 yr.	0	Large hernia. Developed lobar pneumonia third postoperative day
4. J.P.	55	2-22-40	1 yr.	0	Large hernia
5. R.M.	26	5-28-40	10 mos.	0	
6. G.G.	5	11-5-40	6 mos.	0	
7. C.S.	4	1-8-41	2 mos.		
8. G.S.	51	2-21-41	2 mos.	?	Scrotal hernia; large rings
9. S.P.	14	3-4-41	2 mos.	0	
10. A.D.	23	3-6-41	2 mos.	0	
11. M.S.	22	4-24-41	3 wks.	0	Scrotal hernia

as the inguinal ligament in order to expose adequately the abdominal inguinal opening. With good relaxation of the abdominal muscles the rectus muscle now can be retracted laterally, thus exposing the "ring," which is identified by locating the inferior epigastric vessels (Fig. 7, c; cf. Fig. 6); it is seen to lie across the inguinal ligament from the femoral "ring," in relationship to which it lies slightly anterior and lateral. The hernial sac is easily recognized as it enters the inguinal canal. Occasionally it is necessary to ligate and divide the epigastric vessels which may lie across the inferior margin of the "ring," in order to facilitate mobilization of the sac. Gentle traction on the sac at the level of its junction with the peritoneum, together with combined blunt and sharp dissection, results in its easy separation from the other cord structures in the canal (Fig. 7, d). A sac which descends into the scrotum, or one associated with dense adhesions, may offer difficulty; in such instances it may be necessary to section and leave a portion of the sac. After removal of the sac (Fig. 7, e) the abdominal inguinal hiatus is closed with two or three interrupted silk sutures which merely approximate the transversalis fascia across the opening (Fig. 7, e). It is felt that, unless the aperture is so large that it comes to underlie the subcutaneous inguinal opening, thus producing in effect a direct hernia, the obliquity of the angle by which any secondary peritoneal protrusion would have to enter the newly closed abdominal "ring," together with the strength of the intact wall, are sufficient to insure against any danger of recurrence. The operation is concluded by the suture of the fascia in the midline (Fig. 7, f), and the approximation of the incised skin margins with interrupted silk sutures or Michel clips.

The advantages of such a procedure are several: protection is offered against recurrence afforded by the avoidance of distortion trauma and the formation of scar tissue in the vulnerable inguinal area; the technique itself is much simpler than that employed in the orthodox methods for repairing an indirect inguinal hernia; the procedure can be carried out more rapidly; there is little danger of injury to the ilioinguinal nerve and to the structures of the spermatic cord; finally, there is less likelihood of wound infection than with an inguinal incision.

It should be pointed out, however, that the operation has certain limitations. Obviously, such a method of repair is unsatisfactory for a direct inguinal hernia and for a large indirect hernia in which the orifices of the canal have become so dilated as to create a window in the inguinal wall. The latter should be recognized and repaired in the same manner as a direct hernia. Good relaxation of the abdominal wall is essential to adequate exposure when the midline approach is used; hence the use of gas anesthesia is excluded. Novocain infiltration anesthesia offers greater difficulty than it does with the inguinal approach, because of the necessity of infiltrating a much wider area. The danger of entering the peritoneal cavity might be considered an objection to any retroperitoneal approach. However, we are of the opinion that such an accident is not of serious importance; in only one of our cases was the peritoneum opened, and this was repaired at once with no subsequent disadvantage to the patient.

We have operated upon 11 patients during the past 2 years using the technique described. It is appreciated that such a small series of cases, only 5 of which have been followed for a year, can hardly be entered as proof of this method's superiority over other procedures. However, a number of interesting observations have been made in following this group

which deserve recognition (Table II). An elderly obese male (Case 3, D.P.), was operated upon 14 months ago under spinal anesthesia for a large right indirect hernia; on the third postoperative day he developed type VII bilateral lobar pneumonia; there followed 2 weeks of violent coughing without damage to the repair and when he was last examined, 13 months after operation, there was no evidence of recurrence. Another patient (Case 2, C.H.) was operated upon for a scrotal hernia, and it was necessary to leave the scrotal portion of the sac because of dense adhesions; when last examined, 12 months later, there was no evidence of hernia or hydrocele although this patient has been at his regular work (manual labor) since the second postoperative month. The youngest patient in the series was 4 years of age, the oldest, 62. All cases have been accepted without regard to the size of the inguinal "rings," although it is felt that the procedure should not be used in cases in which these apertures have been dilated to a condition which constitutes a direct opening in the abdominal wall. There have been no recurrences in any of the cases followed for a period beyond 3 months (2 patients recently operated upon have not been re-examined).

CONCLUSIONS

A re-study of the anatomy of the inguinal canal by means of dissections which begin with the abdominal inguinal hiatus and proceed through the successively deeper layers, indicates the accessibility of a hernial sac from a retroperitoneal approach and serves to re-emphasize the importance of the peritoneum and transversus abdominis layer and the transversalis fascia in determining the strength of the abdominal wall about the inguinal canal. In the specimen illustrated — and in many others examined during the progress of laboratory study—the inferior part of each of the abdominal layers is found to be an almost totally fascial area; aponeurotic fibers and muscle fascicles are sparse in the lower inguinal territory. The transversus abdominis and the internal oblique are there quite uniformly thin, while the external oblique is locally weak at the intercrural hiatus in its aponeurosis; these strata, with the preperitoneal and peritoneal layers, all are to a degree attenuated where, in the form of funicular investments, they are prolonged from inguinal to scrotal level as a set of concentrically lamellated sacculations. When, in a case of indirect inguinal hernia, the innermost, or peritoneal, sac is occupied by herniating intestine or omentum, the other saccular extensions share in its dilatation; as a consequence, the wall of each sac is stretched, the abdominal orifice of each is dilated and displaced.

In the restoration of an adequate parietal barricade to hernia the serous sac is, of course, the fundamental anatomical element; its space is the only true inguinal "canal." Since its congenital presence offered the initial route for hernial progress, its obliteration logically constitutes the primary step in surgery of repair. Furthermore, in carrying out the ligation of the peritoneal sac, that method would seem most rational which brings minimal distortion and stretching to overlying parietal layers which have already been inordinately stretched.

A method of repair for indirect inguinal hernia which is designed to preserve intact the transversalis fascia and other structures about the inguinal canal, and which simplifies high ligation of the sac, is described. To date 11 patients have been operated upon, and of these 6 have been followed for a period longer than 6 months with no evidence of recurrence. We believe that the operation is anatomically sound, and we are confident that it provides certain definite advantages over the conventional methods.

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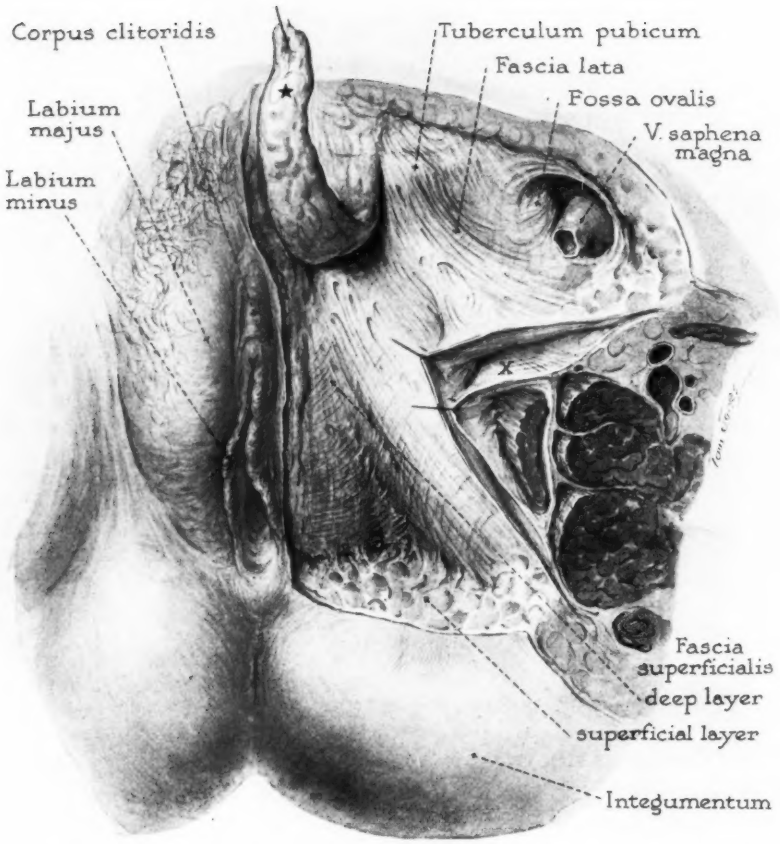

Fig. 1. Female perineum. Subcutaneous layers; specimen I. On the (observer's) right side the superficial layer of the superficial fascia has been removed to expose the deep (Colles') layer in the anterior (urogenital) part of the perineum; in the posterior (anal) part of the perineum the superficial layer, locally thickened and adipose, remains intact behind the line of cut, i.e., in the ischiorectal fossa. The sleeve of fascia lata, shown by transecting the thigh, has been freed from the muscle fascia; the latter is shown as it invests the sartorius (at *x*) and the adductors, freed from the muscles and retracted. The diverticular process has been mobilized and lifted (marked with star). On the opposite half of the perineum the skin remains intact. Successively deeper dissections of the same specimen follow (Figs. 2 to 4).

Further Studies in Gynecological Anatomy and Related Clinical Problems.—Arthur H. Curtis, Barry J. Anson, and Franklin L. Ashley

FURTHER STUDIES IN GYNECOLOGICAL ANATOMY AND RELATED CLINICAL PROBLEMS

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IN continuing a re-study of the female pelvis and perineum in relation to the modern practice of surgery, additional anatomical features of gynecological importance have been established. Since many of these features are quite evidently not known to anatomists or surgeons because of dependence upon stereotyped accounts, the authors believe that a record of their experiences should prove serviceable.

In this third contribution concerned with a further study of the female pelvis and perineum, fifteen life-sized drawings were prepared by Tom Jones from three specimens.[1] Each drawing is an exact portrayal of the anatomy of a particular phase of the dissection, and none is a composite picture.

I. PERINEUM: SUPERFICIAL LAYERS

The superficial fascia of the perineum is fatty and is divided by heavy bands of fibrous tissue into lobules. The bands, in attaching themselves to the deep membranous layer in the urogenital part of the perineum (Fig. 1), render it difficult to find a definite plane of cleavage.

The fatty layer is relatively thin in the anterior part of the urogenital subdivision of the perineum, but it increases in bulk as the base of the urogenital diaphragm is approached (Figs. 1 to 4). The greater lips are mound-like (Fig. 1), the elevation on each side being due in large measure to the presence of a fatty diverticular extension, into the labial tissue, of the inguinal superficial fascia (Figs. 2 and 3).

The prolongation is tapered and bluntly pointed (Figs. 1 and 3). This fatty process lies against the deep layer of the superficial fascia; therefore, in palpating the deeper perineal structures, the bulb of the vestibule is not felt; it is masked by the presence of the more superficially placed fatty process,[2] which is definitely demarcated from the surrounding tissue in which it is embedded, resembling a finger-like lipomatous tumor. Into it, for a short distance beyond the level of the subcutaneous inguinal ring, all the layers of the inguinal parietes are traceable as exceptionally thin investments (see Anson and Ashley, 1940). It contains the round ligament, which is, however, soon lost in the tissue which houses it.

The deep (membranous) layer of superficial perineal fascia is as distinct from the overlying fatty pannicle as the corresponding abdominal layer of Scarpa is from the layer of Camper (Figs. 1 and 2). The deep layer of superficial fascia is firmly attached at the sides along the ischiopubic rami; behind it fuses with the inferior fascial layer of the urogenital diaphragm; in front it is continuous, over the pubis, with the layer of Scarpa on the abdominal wall. The layer is complete, usually, save for the presence of small hiatuses—placed chiefly at the dorsal margin for the transmission of the clitoridal branches and tributaries of the pudendal arteries and veins; posterior labial vessels sometimes pass through lesser hiatuses.

II. PERINEUM: SUPERFICIAL COMPARTMENT

On the next deeper level, within the superficial perineal compartment, lies the inferior perineal fascia (of Gallaudet); it is a thin, yet clearly

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[1] As in previous contributions the accompanying illustrations are two-thirds actual size. Specimen I (Figs. 1 to 4) was a white female, 30 years of age, of average height, weighing about 90 pounds embalmed. Specimens II (Fig. 5) and III (Figs. 6 to 15) were also white, of approximately the same age, et cetera. All were entirely free from gross pelvic or perineal pathology. In the current and in the preceding study (Curtis, Anson and Beaton, 1940) specimen III was employed for 10 and 7 illustrations, respectively; Figure 6 of the current set continues the dissection from Figure 7 of the earlier series. These two sets of illustrations constitute an atlas of musculofascial anatomy extending from the peritoneum, on the pelvic aspect, to the superficial perineal muscles on the perineal aspect of a single female specimen. It is the belief of the authors that such an inclusive treatment of an anatomical region in one specimen is unique. Specimen I was used in the detailed study of the superficial strata, specimen II for special dissection of the external anal sphincter.

[2] The fatty process is 8.5 cm. long (measured from its root at the subcutaneous inguinal ring); it is 1.5 cm. wide at the midpoint. It extends posteriorly to a point opposite the hinder limit of the vestibule; its failure to turn medialward in the area between the vestibule and the anal orifice accounts for the indistinctness of the posterior labial commissure.

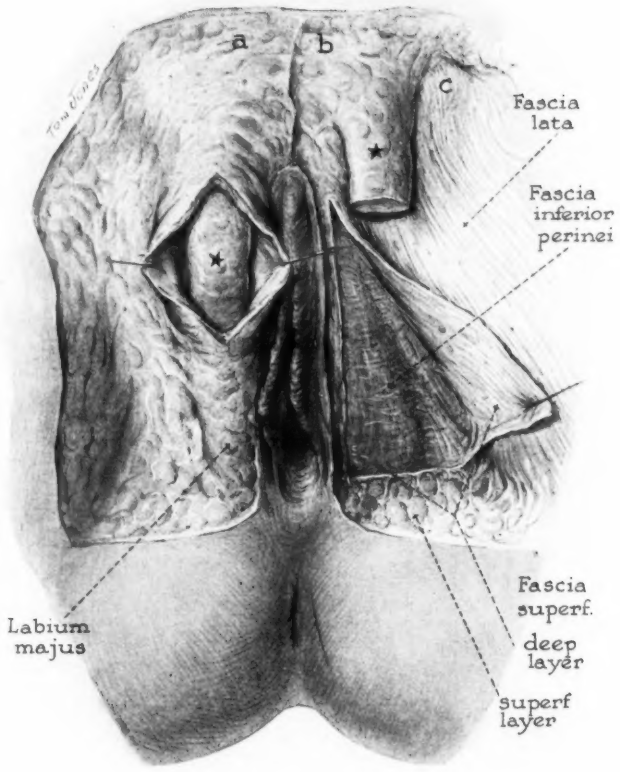

Fig. 2.

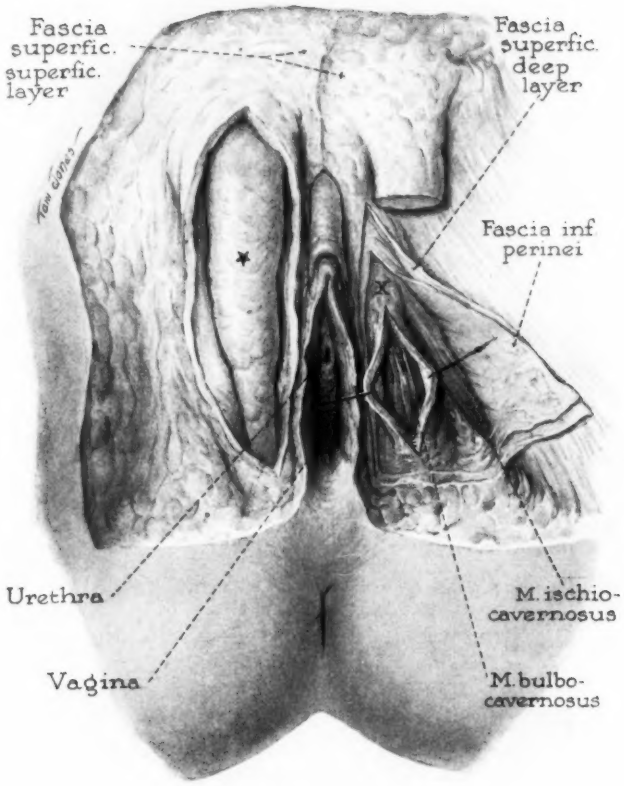

Fig. 3.

(*Legends on opposite page*)

separable, layer of deep fascia (Figs. 2 and 3). Like a typical deep fascia (e.g., of thigh, at *X*, in Fig. 1), it can be lifted away from the bulbocavernosus and ischiocavernosus as a thin sheet (Fig. 3).

Internal to the inferior perineal fascia just described, immediately investing the bulbocavernosus muscle, there exists a much thicker layer which constitutes a rather loose sheath for the muscle (slit longitudinally to *X* in Fig. 3). As determined by an examination of microscopic section, this sheath is chiefly fibrous; however, it contains scattered fascicles of skeletal muscle. Apparently this ample sheath, not merely the muscle enveloped by it, is employed by Martius in his operation for relief of incontinence due to destruction of the urethra.

The deep layer of the superficial fascia forms the floor of the superficial perineal compartment (Figs. 1 and 2); into it are implanted fibers of the external anal sphincter (Fig. 4; cf. Fig. 5). The roof of this compartment is the inferior fascia of the urogenital diaphragm (Fig. 4; cf. Fig. 8). Since the two fascial layers (and the deeper elements as well) are attached directly to both sides of the pubic arch, they, with the external anal sphincter, form a sling-like support for the pelvic organs which is auxiliary to the pelvic diaphragm; the sling is narrow behind at the coccygeal attachment, broad in front of the ischial tuberosity (Figs. 8 and 9). Within the superficial perineal compartment are contained the bodies of erectile tissue and superficial perineal muscles which are related to them; the muscles are, on each side, the superficial transverse perineal, the bulbocavernosus and the ischiocavernosus (Figs. 4 and 8).

1. Superficial perineal muscles; vulvovaginal glands of Bartholin.[1] Within the superficial perineal compartment the crus of each side, although small, is definitely outlined, easily palpable against the ischiopubic ramus. The bulb, on the contrary, is so flattened that its limits are not easily discovered.

The bulbocavernosus muscles are situated on the sides of the vestibule (Fig. 4; removed in Fig. 8). As stated, a firm sheath of fibromuscular tissue encases the relatively thin inner layer of muscle, which, in turn, closely invests a bulbus vestibuli. Posteriorly the muscle fibers of the opposite sides join behind the vaginal opening where they meet those of the superficial and deep transverse perineal muscles and the external anal sphincter. Anteriorly, the bulbocavernosus divides, the medial division covering the so called intermediate mass of the erectile tissue; the lateral division covers the ischiocavernosus muscle (Fig. 4). Contrary to accepted belief, it is the firm musculofascial sheath rather than the thin bulbocavernosus muscle which is of value in reconstruction operations on the female urethra, such as that employed by Martius. The fibrous tissue of the bulb and the underlying firm tissues of the urogenital diaphragm offer additional surgical support (Figs. 8 to 11).

The paired vulvovaginal (Bartholin) glands, outgrowths from the epithelium of the urogenital canal, are immediately adjacent and posterior to the bulbs, where they lie buried in cellular tissue, not definitely within the deep perineal compartment, as commonly described, but at the base of the compartment where the division between the

Fig. 2. On the left, the superficial layer of the superficial fascia has now been exposed by reflection of the skin; it has been incised longitudinally where it covers the labial portion of the diverticular process (at star), the width of the latter demonstrated by retraction of the margins of the incision. On the right, the deep layer of the superficial fascia has been cut, the flap turned lateralward, to show the inferior perineal fascia as the latter covers the muscles in the superficial perineal compartment. In the anterior portion of the anal part of the perineum, on each side, much of the fat of the superficial layer has been removed from the ischiorectal fossae; over the front of the pubis it has been removed in three levels to show, successively, the immediately subcutaneous tissue, *a;* the covering of the diverticulum, *b;* the diverticulum itself, at star; and the subjacent fascia lata, *c*.

Fig. 3. On the left side the fatty inguinal process (at star) has been further freed from the superficial layer of the superficial fascia by retraction of the margins of the now lengthened labial incision. On the right the corresponding structure has been transected at pubic level; the membranous (deep) layer of the superficial fascia and the muscle fascia have been reflected. Over the bulbocavernosus muscle the thick fibrous investment has been incised (to point marked X), the margins retracted. Here five successive strata are demonstrated (skin to muscle).

[1]Very frequently it is important to know the dimensions of structures in the perineal compartments; equally important may be their relation to palpable landmarks. Since such data are almost totally absent from standard descriptions and excessively rare in the literature, it is thought worthwhile to furnish records of this kind, especially where they are directly referable to accurate drawings made from the dissections illustrated.

For specimen I (see esp. Fig. 4) the following measurements may be recorded. The ischiocavernosus muscle is 10 cm. long, 1 cm. wide at the midpoint. The bulbocavernosus is 7.5 cm. long; the maximum width is 1.6 cm. (mid-bulbar); the thickness is 1.0 mm. The vulvovaginal (Bartholin) gland is 0.8 cm. long, 0.35 cm. wide. From the medial extremity the duct is given off; the latter is 1.25 cm. long. It empties into the vestibule 1.8 cm. from the anterior limit, 1.6 cm. from the posterior (measured along an anteroposterior midline). The duct is 0.1 cm. in diameter at the termination, 0.15 at the origin. The superficial transverse perineal muscle (each) is 0.3 cm. thick (at midpoint), 4.2 cm. long (to midline from tuberosity). The external anal sphincter ani is 7.3 cm. long (tip of coccyx to perineal body), 1 cm. wide. On the lateral wall of the ischiorectal fossa, the distance between the urogenital and the pelvic diaphragm is 3.5 cm. (this is the height of the anterior recess of the fossa at the latter's posterolateral boundary). Along the same line, the distance from the pelvic diaphragm to the surface of the skin is 6.5 cm.—which is the depth, incidentally, of the mass of the fat filling the fossa; it is 3.0 cm. from the urogenital diaphragm (inferior fascia) to the skin.

In specimen III the superficial transverse perineal muscles together are 10.5 cm. long, which measurement is also that of the maximum width of the urogenital triangle. Each muscle is 0.2 cm. thick, 0.3 cm. deep, and 0.7 cm. wide. The fibers of the ischiocavernosus muscle extend to a point 3 cm. beyond (dorsalward) the attachment of the clitoridal crus.

superficial and deep compartments is not clearly defined (Fig. 4). The body of the gland is transversely placed on a level with or slightly deeper than the bulb, parallel with its base, the duct passing medio-anteriorly at an angle of approximately 75 degrees and directed slightly outward toward the vulva. The Bartholin glands are not palpable when normal, since their outlines are masked by enveloping structures (Figs. 3 and 4). When diseased, because limited posteriorly and superficially by firm musculofascial tissues, they enlarge in the direction of least resistance, often to a depth of several centimeters, and extend anteriorly, palpable at the point of junction of the middle and posterior thirds of the vagina.

The superficial transverse perineal muscle, slender, yet definite, arises out of the trigonal musculature, as if it were a true derivative thereof (Figs. 4, 8 and 9; exposed in Fig. 9 by removal of bulbs and fascia). Posteriorly, the superficial transverse perineal muscle lies directly against the external anal sphincter (Fig. 8); anteriorly it almost reaches the posterior wall of the vagina (Fig. 9). At the central tendinous point the deep and superficial transverse perineal muscles merge, and with them the external anal sphincter and bulbocavernosi. The superficial transverse perineal muscle is important as a surgical landmark, for around its posterior border near its origin from the tuberosity of the ischium the pudendal nerve and artery turn upward to reach the perineum (Figs. 8 and 9). Here one may block the pudendal nerve for obstetrical delivery; destruction of its anterior perineal branches and ramifications is resorted to for relief of pruritus vulvae.

Each ischiocavernosus muscle begins well back on the tuberosity of the ischium, its hinder fascicles being traceable to the point at which the posterior fibers of the urogenital diaphragm arise (Fig. 10). Anteriorly, muscle fibers give way to aponeurosis halfway between the tuberosity and the pubic arcuate ligament (Fig. 9). The investing fascia (inferior perineal fascia) which then continues onward covers the front of the pubis (and clitoridal body in specimen III; Fig. 9). On the abdomen it becomes the outer investing layer of the external oblique (McVay and Anson, 1938). The muscle and the outer investing fascia are separable from the tissue of the erectile crus; when removed (Fig. 10), a very heavy tunic is exposed.

2. Erectile bodies.[1] The vestibular bulbs are much less vascular than conventional figures would lead one to expect; they are composed chiefly of fibrous material resembling that of the tunica albuginea of the testis. This is in accord with surgical experience; the erectile tissues, reputedly extremely vascular, are not more than generously so, and constitute no particular hazard at operation.

In one of the specimens (No. III) the conjoined bulbs are not connected anteriorly with the conjoined crura; that is, there is no intermediate mass between pairs of erectile bodies; differing from the arrangement usually described, the bulbs, then, do not contribute to the formation of the clitoris (contrast specimen in Fig. 6, Curtis, 1938), the inferior perineal fascia completely separating the sets of erectile bodies. This fascial layer, in specimen III, forms a complete envelope for the pubic extremities of the clitoridal crura, covering the inferior surface of the conjoined ends so that the body of the clitoris appears merely as an elevation (Fig. 9), investing the superior surface and resting upon the pubic symphysis (Fig. 10). Continued upward to inguinal position, the fascia becomes the innominate fascia (trimmed around the clitoridal body in Figs. 9 and 10). The extent to which the clitoris is covered by heavy fibrous laminae doubtless accounts for the fact that its plexiform content occasions little difficulty in lacerating injuries to the perineum. In some specimens (e.g., specimen III in the current group) vascular tissue is slight in amount, the fibrous capsule being the more prominent as seen in gross section; in others (e.g., specimen I) the type of plexus present is that usually illustrated in textbooks.

III. PERINEUM: DEEP COMPARTMENT[2]

The roof of the superficial perineal compartment is, at the same time, the floor of the deep compartment (Fig. 8); it is one of the two fascial

[1] In specimen III the body of the clitoris is 2.6 cm. and 1.0 cm. wide; the urethra opens 2.3 cm. posterior to the tip of the glans. The anterior end of the clitoris is removed by a distance of 2 cm. from the pubic crest, by 7 cm. from the central tendinous point of the perineum. Posteriorly, between the fossa navicularis and the anal sphincter (which latter overlaps and obscures part of the bulbs) the bulb is 1.5 cm. wide. The maximum width of each bulb is 2 cm.; narrowing anteriorly, each is joined by a crus—at a distance of 4.5 cm. from the central tendinous point. At the middle, each crus is 0.5 cm. in width, twice that wide near the anterior end.

In specimen I each bulb is 4.7 cm. long (to point of anterior fusion), 1 cm. wide (maximum), 0.5 cm. thick. The intermediate mass is a strand 1 cm. long, 0.2 cm. thick. It joins the body 0.6 cm. proximal to tip, 0.6 cm. distal to the point at which the body becomes free, and 3.3 cm. distal to the superior or anterior limit of the clitoridal body. The body of the clitoris is 1.1 cm. wide at the broadest part, 0.2 cm. at the narrowest (just proximal to the "glans"). The full length of the clitoris is 4 cm., that of the free part is 1.3 cm.; the maximum height is 1.2 cm. (at the proximal end of the free portion).

[2] The muscular part of the urogenital diaphragm in specimen III is 10.5 cm. in maximum width (at base); two-thirds of the width is made up of musculature, one-third is space (vestibule, vaginal orifice). The main part of the diaphragm is 4.5 cm. long (measured in the median line from the pubic arcuate ligament to the deep transverse perineal muscle); the thickness varies from 0.5 to 0.7 cm. The deep transverse perineal muscle is about 1.5 cm. wide.

At this level the following additional measurements are important; depth of the pubis at symphysis, 4.5 cm. (measured in the plane of symphysis); distance from the superior border to the tip of the glans, 3.2 cm.; width of vestibule, 2.5 cm.

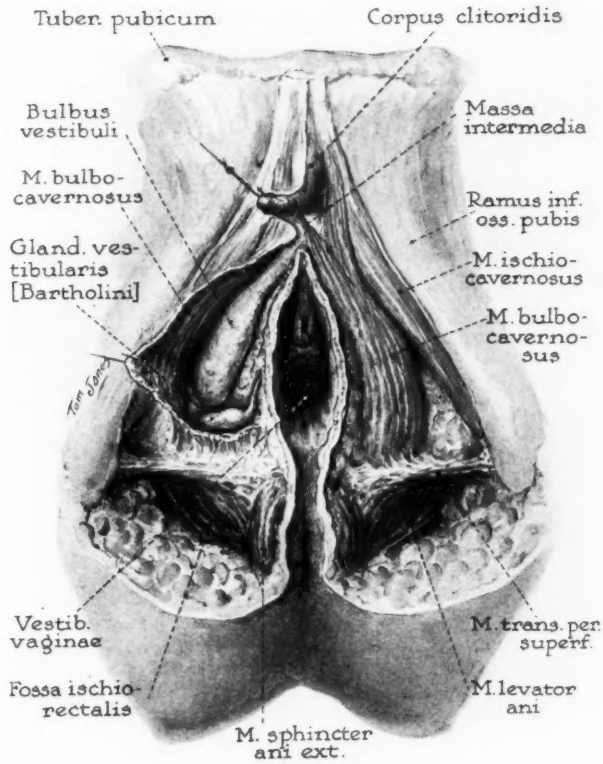

Fig. 4. In the anal part of the perineum the levator ani and external anal sphincter muscles of each side are shown by removal of the superficial fatty tissue. In the urogenital part of the perineum, on the right side, by cutting away the muscle fascia, the ischiocavernosus, superficial transverse perineal, and bulbocavernosus muscles have been brought into view. On the left side the bulbocavernosus muscle has been reflected to expose the bulb of the vestibule and greater vestibular (Bartholin's) gland and duct. Anteriorly are seen the glans, body, and intermediate mass of the clitoris.

laminae which invest the musculature of the urogenital diaphragm; the "fasciae" (ofttimes as strong as aponeuroses), together with the muscle, make up the diaphragm.

The urogenital diaphragm is regularly described as triangular in outline; actually it is of quadrangular form. The pouch which its fascial layers forms does not completely segregate the contained muscles, since the deep and the superficial transverse perineal muscles blend medially (Fig. 9). The musculature not only serves as a urethral sphincter (sphincter urethrae membranaceae) but extends superior to the coccygeal extension of the external anal sphincter to a firm coccygeal insertion (Fig. 10). In this respect it resembles the pubococcygeal part of the levator ani (Figs. 6 and 7). When the urogenital diaphragm has been entirely separated from its posterior attachments, and reflected, the pelvic diaphragm still remains as a complete partition (Fig. 12). Thus, the urogenital diaphragm does not fill a defect in the pelvic diaphragm but, rather, constitutes an additional re-enforcing layer for support of the pelvic organs.

In the specimen illustrated, a subdivision of the muscular components of the diaphragm into deep

transverse perineal muscle and urethral sphincter is not apparent (Fig. 9). The deep transverse perineal muscle of the urogenital diaphragm does not terminate sharply along a transverse line; a triangular prolongation passes backward, on either side of the rectum, deep to the coccygeal extension of the sphincter ani (Fig. 9). The full extent of this prolongation of the urogenital diaphragm is revealed when the anal sphincter is removed (Fig. 10). The fascicles of the two sides converge, intermingle behind the anal canal, and extend to a narrow coccygeal attachment, lying between the anal sphincter and the pelvic diaphragm; considering this hitherto undescribed element as an integral part of the urogenital diaphragm, the latter is, as previously stated, quadrangular, not triangular. Many of the backward-directed fibers from the urogenital diaphragm penetrate the substance of the anal sphincter around its anterior three-fourths, interdigitating with these fibers and with the downward continuation of the levator ani (Figs. 10 and 11); other fibers continue around the anal canal to meet those of the opposite side, to become merged in the midline with an aponeurotic thickening. The latter continues to the coccyx, lying beneath the sphincter ani and conforming to its contour (Fig. 9; cf. Figs. 10 and 11).

In the posterior part of the diaphragm, the whole layer of urogenital musculature is laminated, partially separable into strata by incomplete fascial plates (Fig. 11). Transversely directed fibers of the part of the urogenital diaphragm between the anal and vaginal canals lie just beneath the superficial transverse perineal muscle (Fig. 10); those fibers which pass in exactly transverse course are elevated somewhat on the anterior wall of the anal canal (Fig. 11, level 1); they lie deep to the external anal sphincter and the superficial transverse perineal muscle. From a slightly deeper level appear fascicles which, following a more oblique course, ultimately reach the sides of the anal canal (Fig. 11, level 2). The coccygeal prolongation of the diaphragm arises from a still deeper level; the fibers, beginning near the tuberosity of the ischium, at first pass medially; then, turning posteromedially as they skirt the anal canal, they course toward the coccyx (Fig. 11, level 3). The urethra, then, receives a considerable muscular support; on the perineal aspect sphincter fibers pass into and in front of the urethra (Figs. 9 to 12), downward upon it (Fig. 13, urethra retracted), and behind it (Figs. 12 and 13; at star, mucous membrane removed). The latter band is available for surgical correction of urethrocele (see Fig. 221, Curtis, 1938). On the pelvic aspect this support is augmented by similar contributions from the pelvic diaphragm, the anterior band of fibers (Fig. 6, at arrow) bounding the inconsiderable perineopelvic hiatus. In some specimens the musculature of the urogenital diaphragm seems to be developmentally defective, the deep compartment containing a venous plexus which is actually bulkier than is its muscular content. Our clinical observations, directed to this feature, indicate that many cases, subjected to the rigors of childbearing, are predisposed to urethral sagging because the urogenital support is congenitally weak.

The deep layer of the urogenital diaphragm is distinct from the levator ani against which it lies (Fig. 12); there is no heavy fascial stratum between the apposed layers of musculature of the two diaphragms. Although in the middle two-fourths of the width of the urogenital diaphragm in the anovaginal area the anal and urogenital diaphragms are in apposition, fibers are not exchanged between them to a noteworthy degree.

For a discussion of the musculofascial sheaths of the pelvic viscera, which are so important in the repair of cystocele and rectocele, the reader is referred to earlier articles in this series (Curtis, Anson and McVay, 1939; Curtis, Anson and Beaton, 1940). The current study has impressed the authors forcibly with the importance of the support afforded by the urogenital and pelvic diaphragms in the repair of cystocele and rectocele, reaffirming previous evidence that the musculofascial collars of the viscera are the chief support. Comparison of dissected material with corresponding tissues in patients subjected to cystocele and rectocele operations reveals the fact that there is commonly great hypertrophy of the supporting fascia in pathological cases, the degree of hypertrophy being in general proportionate to the duration and extent of the lesion. The urogenital diaphragm and the pubococcygeal part of the pelvic diaphragm play a considerable rôle in the control of incontinence in cystocele cases; transverse mattress suture of the fibers lateral to the floor of the urethra (Fig. 12) is advisable in all cystocele cases with urinary leakage. In those infrequent cases in which dribbling persists after an apparently successful operation, a satisfactory result may be obtained by bilateral snugging up of the fibers of the pubococcygeus which normally maintain the urethra in close attachment to the pubis (at arrow in Fig. 6, at star in Fig. 13).

In making a lateral or a median episiotomy, and in the tearing and retraction which accompanies labor, the tissues of both diaphragms are involved

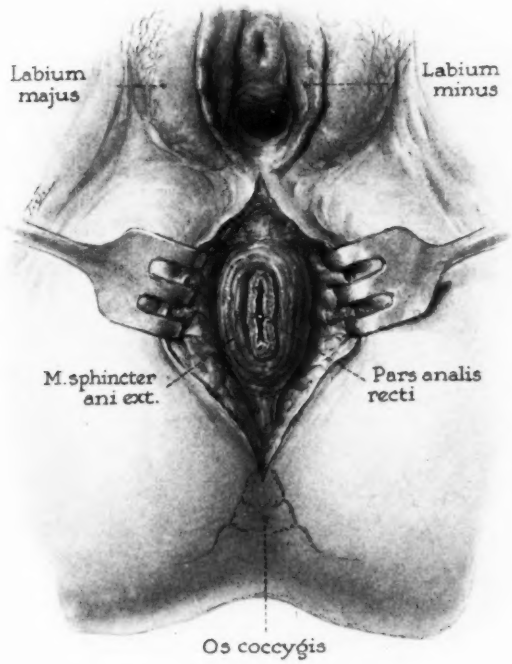

Fig. 5. Female perineum; specimen II. External anal sphincter; exposed by merely reflecting the skin. The position of the coccyx is indicated by dotted line.

(Figs. 8 to 14). An anatomic feature of clinical importance merits emphasis in this connection; the pelvic and urogenital diaphragms are in close apposition in approximately the median two-fourths of the diameter of the outlet: lateralward they diverge greatly, being separated by the anterior recess of the ischiorectal fossa. However, in the entire region subjected to perineal surgery the two diaphragms are in apposition, the urogenital diaphragm comprising perhaps four-fifths of the thickness, the levatores one-fifth. The urogenital diaphragm is more dense and firm, and thicker than the pubococcygeus of the levator ani with which it makes a surgical unit. Together they constitute the so-called "levator ani" of clinical parlance.

IV. PERINEUM: ANAL MUSCULATURE

1. External anal sphincter. In a perineal approach to the structures which close the pelvic outlet, the external anal sphincter is the first muscle encountered; it is subcutaneous in position, broad but thin (Figs. 5, 8 to 10).

The muscle is an orbicular sphincter, with a prominent coccygeal extension commonly called the anococcygeal ligament. Anteriorly it overlaps the conjoined bulbs of the vestibule, and into it are implanted the small superficial transverse perineal muscles. It is readily dissectable from neighboring structures (Figs. 8 and 10). Owing to the proximity of the external anal sphincter to the cutaneous surface, the surgeon has difficulty identifying this structure at operation, further handicapped as he is by retraction of the injured tissues and by pathological changes.

Although a single partial division of the muscle incident to hemorrhoidectomy usually leaves a competent sphincter, a complete tear of the perineum does not; sphincteric incompetence results from retraction of the torn ends of the muscle, and from concurrent tearing of the urogenital diaphragm and the levator ani (Figs. 9 to

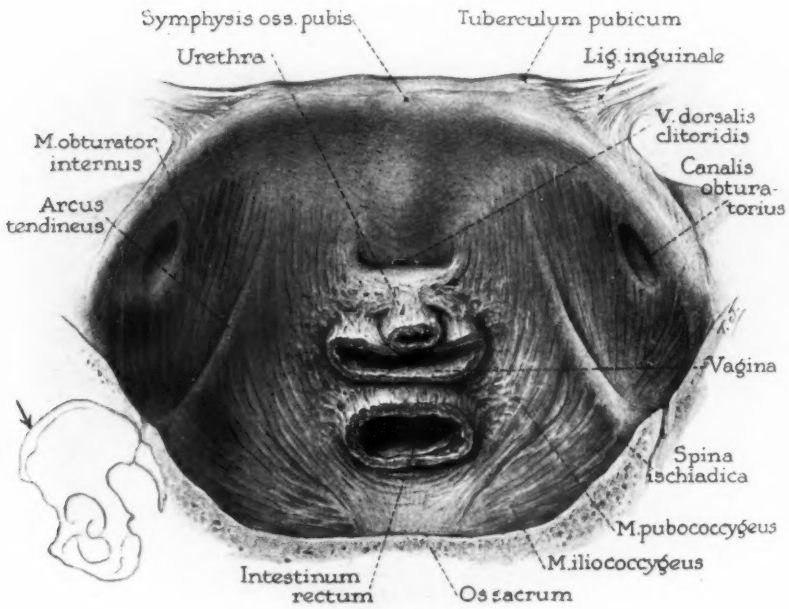

Fig. 6. Female pelvis; specimen III, viewed from above and behind; looking into the "visceral," or anterior, portion of the pelvic bowl (see inset; arrow indicates direction of view). The musculature is exposed by complete removal of retroperitoneal and ligamentous structures, and of the fascial lining of the pelvis (including the endopelvic fascial continuations upon the viscera). The curved arrow indicates the direction of muscle-fibers in the urethral portion of the pubococcygeus. The urethra, vagina, and rectum have been transected near their points of passage through the pelvic diaphragm. Successive dissections of the same specimen follow (Figs. 8 to 15).

12). In the procedure of repair, the operative exposure of choice is a preliminary curvilinear incision around the anus, the vaginoperineal flap turned down over the anal aperture, followed by dissection of the retracted tissues, all proportionate to the extent of the lesion. Restitution of the injured sphincter, urogenital diaphragm, and levator ani by sutures anterior to the rectum and anus is usually made without identifying the details of each anatomical component, although the circularly disposed firm fibers of the sphincter ani, hidden in the more superficial fibrous and fatty tissues, are in sharp contrast with the bundles of longitudinally directed levator ani at a deeper level closely applied to the rectal core.

V. PELVIS: PERITONEUM AND SUBPERITONEAL TISSUES

In an earlier article in this journal (Curtis, Anson and Beaton, 1940) the anatomy of the pelvic peritoneum and subserous tissues was fully described. It was therein stated that the general cellular tissue, the heavy, ligamentous support of organs, and the fascial tubes covering the latter may be even more readily mobilized by gross dissection than they usually are in the course of pelvic surgery, even by those who employ the technique of scissors dissection. Of these various tissues, contrary to Tandler's belief (in Veit-Stoeckel), clinical evidence substantiated by anatomic dissection indicates that the peritoneum serves not merely as a covering, but that, with the contiguous areolar tissue attached thereto, it affords real support.

VI. PELVIS: FASCIA AND MUSCULATURE

1. Endopelvic fascia. That part of the endopelvic fascia which is reflected upward upon the rectum and vagina leaves the pelvic floor at the points at which these organs pass through the

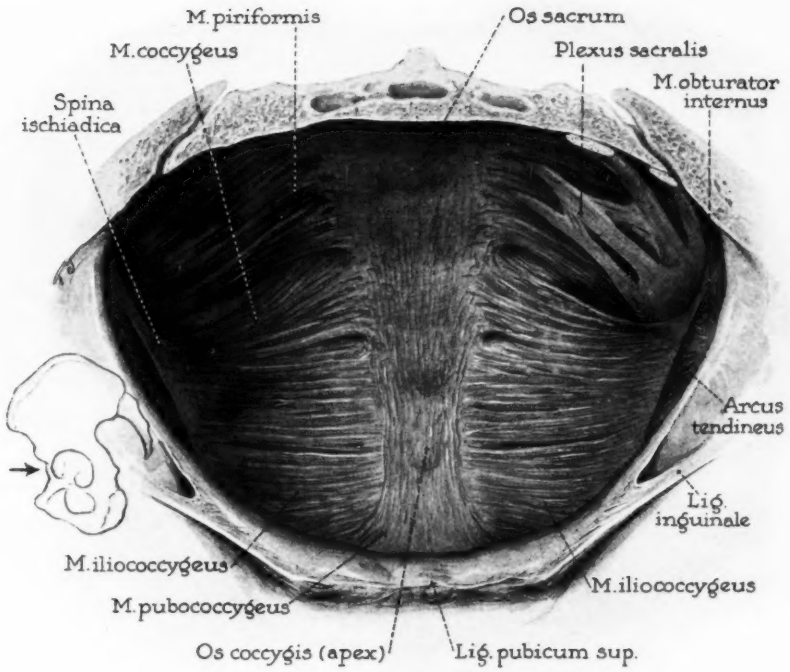

Fig. 7. The same specimen, viewed from the front; looking into the "parietal," or posterior, part of the pelvic bowl (see inset). Dissection as in preceding figure.

diaphragmatic musculature (Curtis, Anson, and McVay, 1939, Figs. 1 and 2). The covering for the bladder, however, is reflected away from the inferolateral walls of that organ in such a way that the urethra receives only a partial investment, being so covered only in front. Since there are three tubes of fascia, in succession, encasing the urethra and bladder, the vagina and lower uterus, and the rectum, there is a double layer of fascia between adjacent organs. In each instance the fascial sheath is in intimate relationship with the musculature of the corresponding viscus, receiving muscle fibers from it. The fascial sheaths, each re-enforced by muscle fibers from the subjacent coat of smooth muscle, are utilized to furnish the major support in the repair of herniations of the tubular viscera, i.e., urethrocele, cystocele, and rectocele. (Particularly in the case of rectocele, and in cystocele with incontinence, repair of the levator ani and the urogenital diaphragm are also important.)

There has been prolonged controversy as to whether the supporting tissue utilized in plastic repair is muscle or connective tissue; likewise, it has been emphasized by anatomists that there is no fascial tissue in these regions sufficiently extensive or firm enough to be of service in repair. A simple explanation suffices. Wherever there is unusual mobility, also under pathological conditions, such as uterine prolapse or cystocele, there are always localized thickenings of the connective tissue. This accounts for anatomists' failure to discover the thick vesicovaginal supportive tissues, an "anatomists' oversight" which aroused Halban's curiosity. Blair Bell's academic insistence that the supportive tissue is muscle, not fascia, meets explanation in the fact that the fascial sheaths derive muscle fibers from the hollow viscera which they surround. Here, too, we meet Tandler's requirement that connective tissue must be associated with muscle in order to be classified as "fascia" and in order to yield real

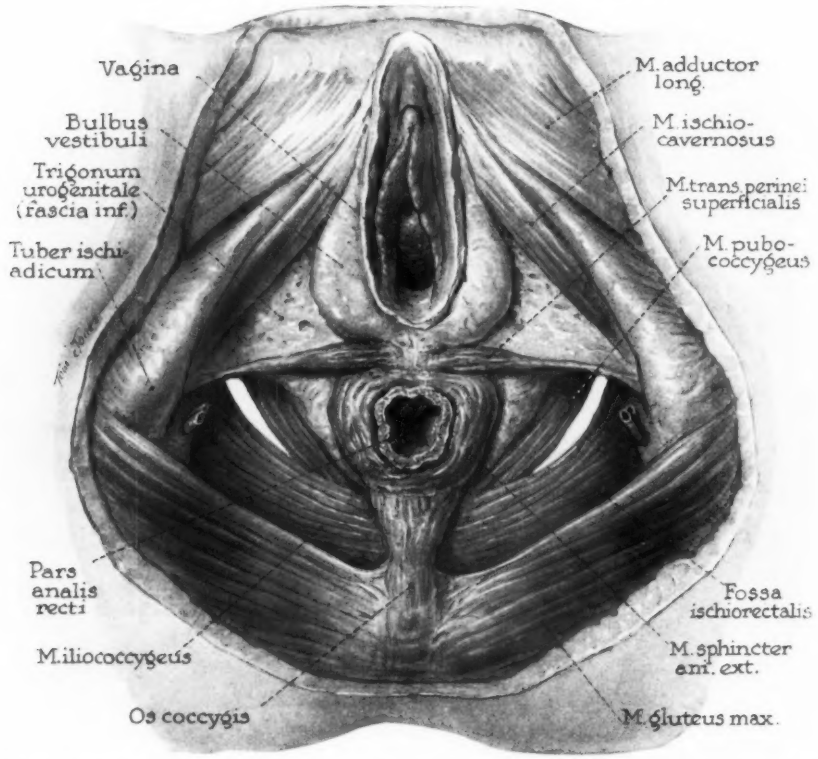

Fig. 8. Female perineum. In the anal triangle the fatty tissue has been entirely removed from the ischiorectal fossae to expose the pelvic diaphragm and the external anal sphincter; with removal, too, of the fascial investments of the levator ani, the cleft between pubococcygeal and iliococcygeal portions is made evident. In the urogenital triangle the layers of superficial fascia have been removed to expose the superficial perineal muscles. The integument of the lesser labia and of the clitoris is intact.

support; those of us who have performed plastic operations require no further evidence in proof of the presence of supportive "fascia" sufficiently strong to hold firmly and permanently in patients with cystocele and uterine prolapse.

The subserous connective tissue (tela subserosa) is of a loose consistency on the inferolateral surface of the urinary bladder (Curtis, Anson, and Beaton, 1940). Between the fascial covering of the bladder and that of the uterine cervix and the vagina the tela connects the fascia of these structures firmly together, yet is separable by blunt dissection where it contributes to the substance of the pillars of the bladder. In dissecting between the two surfaces in complete hysterectomy, in those cases in which there is no pathological thickening of the fascia, the fascial sheath of the bladder and its tela, deprived of the support of the cervicovaginal fascia with its tela, is often hazardously thin, as may be demonstrated through the simple expedient of pre-operative instillation of methylene blue solution into the empty bladder.

2. Pelvic diaphragm and associated muscles.[1] When the superior fascia of the pelvic diaphragm

[1]In specimen III the pubic attachment of the pubococcygeus is 2.5 cm. long; the length of its tendinous attachment is 3.4 cm. Since it is this division of the levator ani that supports the viscera, it may be of importance to note the width opposite each organ, measured from the lateral wall of the viscus to the margin of the muscle, at right angles to the long axis of the muscle: opposite urethra, 4.3 cm.; at vagina, 3.8 cm.; at rectum, 2.4 cm. Posteriorly the muscle narrows as it approaches the coccyx, being 3.2 cm. wide at a point midway between the coccyx and the rectum; at the tip it is 1.7 cm. wide. The retropubic "cleft" is 2.2 cm. wide, 0.7 cm. deep. The preurethral band of the pubococcygeus is 0.7 cm. wide (measured in median sagittal plane). The band which passes transversely between the vagina and the rectum is 2.0 cm. wide; that which passes between rectum and coccyx, is 3.0 cm. The iliococcygeus measures along its origin, 5.3 cm., 6 cm. from its origin to its insertion. Measurements of the coccygeus are: width at origin, 1.8 cm.; at insertion, 5.5 cm.; length, 6.8 cm. Measurements of the piriformis are: width at origin, 4.2 cm.: at foramen, 2.3 cm.; length, 7.6 cm.

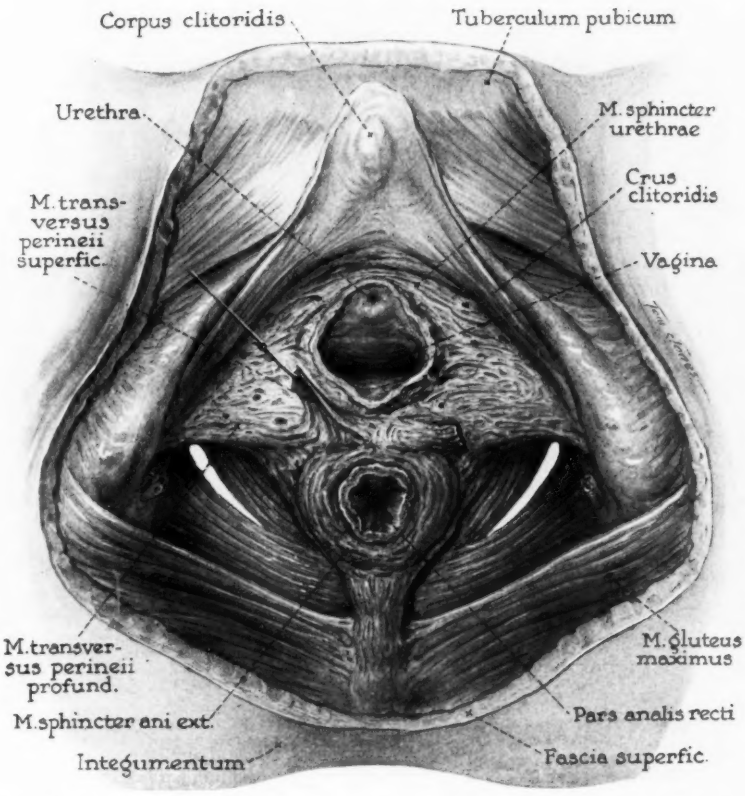

Fig. 9. In the anal triangle the external anal sphincter has been freed somewhat in order to show the coccygeal extension of the urogenital diaphragm. In the urogenital triangle the following superficial structures of the perineum have been removed: the integument and the subcutaneous tissue; the mucous membrane of the vestibular walls; the vestibular bulbs (no intermediate mass present); the inferior fascia of the urogenital diaphragm; some of the more superficial fibers of the urethral sphincter and deep transverse muscles which were attached to the inferior fascia. Shown are the following: the muscles of the urogenital diaphragm; roof of the vestibule, with the vaginal and urethral orifices; a portion of the transverse ligament of the pelvis; the body of the clitoris; the inferior perineal fascia as it invests the ischiocavernosus muscles and covers the front of the pubis; the medial portion of the superficial transverse perineal muscles (stump on left elevated to demonstrate fusion at the central tendinous point of the perineum). The transverse ligament of the pelvis (i.e., the anteriorly fused fascial layers of the urogenital diaphragm) is concealed by the pubic symphysis.

has been removed, the musculature is brought into view (Figs. 6 and 7). The muscles are disposed in two pairs, levatores ani and coccygei. The levatores occupy chiefly that part of the pelvic outlet anterior to coccyx, the coccygei that portion of the outlet behind (and above) the terminal elements in the vertebral column (Fig. 7; cf. Figs. 14 and 15). Together they form a supporting floor upon which the pelvic viscera rest and in which their terminal portions are firmly anchored (Fig. 6), also a dorsal wall for the pelvic cavity (Fig. 7). Each levator ani consists, in turn, of two parts, pubococcygeal and iliococcygeal, which, respectively, serve in the capacities just mentioned. These subdivisions will now be discussed separately, as will also the piriformis and obturator internus muscles which assist in forming the lateral and dorsal walls of the pelvis.

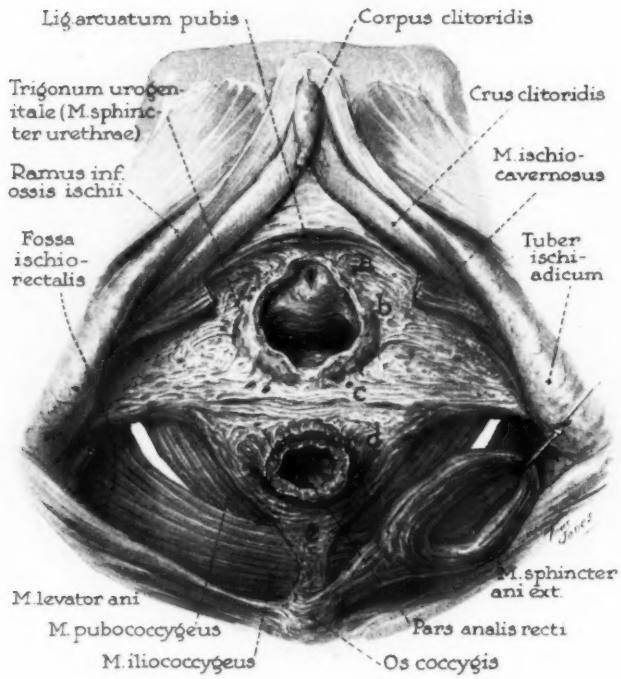

Fig. 10. In the anal triangle the external anal sphincter, now detached from the subjacent muscles of the urogenital and pelvic diaphragms and from the intrinsic musculature of the anal canal, has been drawn aside to reveal the backward-directed fibers of the urogenital triangle; the ischiocavernosus muscles have been rolled medialward away from the crura and the body of the clitoris; the superficial transverse perineal muscles have now been entirely removed to show the course of fibers at the base of the urogenital diaphragm. It is evident that the so called sphincter of the urethra sends muscle fibers not only into and in front of the urethra, at *a;* but also into the vagina, *b;* across the midline between the vagina and anus, *c;* into the wall of the latter, *d;* and backward to the coccyx, *e.*

a. Pubococcygeus muscle. The pubococcygeal muscle is, obstetrically and surgically, the most important muscular element of the pelvic diaphragm, since it serves as a direct support for the bladder and urethra, for the vagina and uterus, and for the rectum. This fact is not made clear in the accounts presented in either surgical or anatomical textbooks; on the contrary, it is everywhere figured as sweeping backward around the organs to leave a very considerable opening in the anterior half of the pelvic diaphragm.

Viewed from within the abdomen (Fig. 6), the pubococcygeal portion of the levator ani is seen to be attached along the pubic bone and the tendinous arch, the latter being the longer origin, the junction of the two forming a peak directed forward. Anteriorly there is merely a shallow hiatus, not a U-shaped cleft. In the midline the dorsal vein of the clitoris passes through this opening into the pelvis, behind the pubic arcuate ligament and in front of the transverse ligament of the pelvis. The anterior fibers which cross transversely in front of the urethra are muscular and form a narrow, but strong, band; those nearest the urethra ascend upon the latter, as also do others from the lateral aspect. Some fibers also descend upon the urethra. The cleft is not seen in perineal view, being concealed by the inferior por-

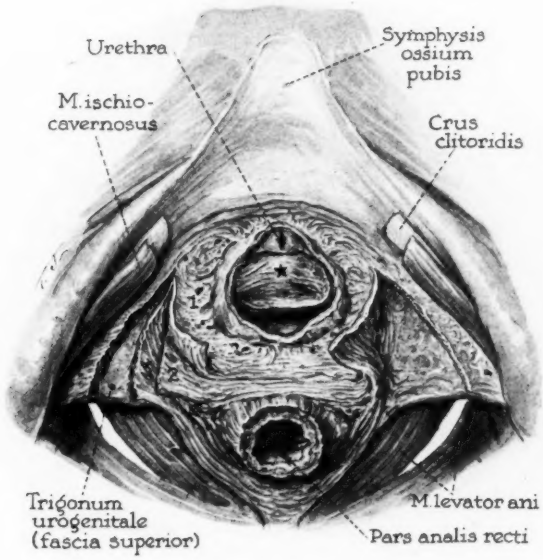

Fig. 11. In the anal part of the perineum the structures remain as in the preceding drawing. In the urogenital part of the perineum, on the right, the musculature is reflected as a single sheet to expose the superior fascia of the diaphragm; on the left its laminated character is demonstrated by making a similar elongate cut, but to depths which mark natural cleavage planes along which the strata are freed for a short distance to either side of the incision. The superficial lamina, *1*, passes chiefly to the vagina, the intermediate one, *2*, into and in front of the anal canal, the deep layer, *3*, backward to the coccyx. The body of the clitoris and the anterior portions of the crura have been removed; the ischiocavernosi remain only at their proximal ends. The mucous membrane has been removed on the anterior wall of the vagina (at star) to show the muscular support derived from the urogenital diaphragm.

tion of the pubis (Figs. 10 to 12). As may be seen from within the pelvis, the "visceral" sets of fibers of the pelvic diaphragm turn quite directly toward each organ, gaining implantation into their walls (Fig. 6). The anterior cleft, then, is very shallow—not evident at all in perineal view (Fig. 9). The urethra is firmly attached to the pubis—a fact of major clinical importance.

In the excavation between the vagina and rectum the narrow anteroposterior band of fibers fastens the organs closely together and ascends upon each tube. Behind the anal canal, many pubococcygeal fibers follow a semilunar course, but the majority pass posteriorly, in a thin sheet, to the coccyx, resting upon the iliococcygeus (Fig. 6; concealed by the latter in pelvic view, Fig. 12).

b. Iliococcygeus muscle. The arciform aponeurotic origin of the iliococcygeus is shared with that of the pubococcygeus (Fig. 6, Figs. 14 and 15, observer's left half of figure). The direction of the fibers is transverse (Fig. 7), in contrast with the arrangement of fascicles in the pubococcygeus, whose fibers are directed somewhat sagitally (Fig. 6).

c. Coccygeus, piriformis and obturator muscles. The pelvic diaphragm is completed on each side posteriorly by a coccygeus muscle (Figs. 7, 14, and 15). The plane of the flat surface of the coccygeus muscle lies at almost a right angle to that of the iliococcygeus. Narrower at the origin than at the insertion, in contrast with the iliococcygeus, the paired muscles fill the space between the iliococcygeus and the piriformis. The fibers of the coccygei do not unite in the midline in a muscular band but are inserted almost entirely into the coccyx by a firm thin aponeurosis.

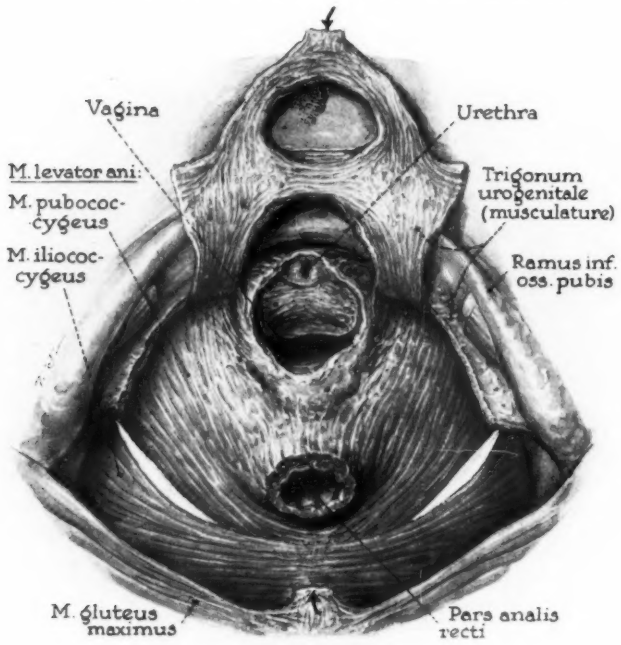

Fig. 12. The urogenital diaphragm has been freed from the pelvic diaphragm, cut along the ischiopubic ramus on each side and at coccygeal apex behind (see arrows), then turned forward on the remaining pubic attachments. The space thus opened into is the anterior recess of the ischiorectal fossa, from which all fatty tissue has been removed. The pubococcygeal part of the levator ani, exposed by removal of its thin investing fascia, is shown to contribute supporting muscle fibers to each of the visceral tubes.

The piriformis muscle partially closes the space of the greater sciatic foramen (Figs. 14 and 15); although belonging to the pelvofemoral group of muscles (like the obturator internus), it serves, to a degree, a diaphragmatic function, since it continues in the stratum of the coccygeus. In the standing position, the muscle is on the wall rather than on the floor of the pelvic cavity.

The importance of the obturator muscle as a parietal element is emphasized by examination of the space which it occupies (Fig. 14, cf. Figs. 6 and 15). The obturator internus fills the lesser sciatic foramen as it passes through the foramen.

3. Pelvic diaphragm as a whole. The three muscles which constitute the pelvic diaphragm proper, and which represent the original tail muscles, i.e., the pubococcygeus, the iliococcygeus, and the coccygeus, all take origin from the pelvic bones. The parts of the levator are either implanted into the walls of the tubular organs for which they constitute a diaphragmatic support or—in the intervals between adjacent organs and in those between organ and bone—join the corresponding muscle of the opposite half of the pelvis. The coccygei, being posteriorly situated, must insert into the sides of the coccyx. In the specimens illustrated a distinct cleft separates the adjacent muscles of the diaphragm, as is apparent when the investing fasciae are removed (Figs. 14 and 15).

The pubococcygeal portion of the levator ani constitutes what might be termed the "visceral" part of the pelvic diaphragm, since it is by this muscle that the terminal portions of the visceral tubes are firmly clasped (Fig. 6). There is no "hiatus of the levator ani" surrounding the visceral tubes at the site of their perforation of the pelvic diaphragm (Figs. 6, 14, and 15); the implantation of the medial fibers of the pubococcygeus firmly into the viscera constitutes a

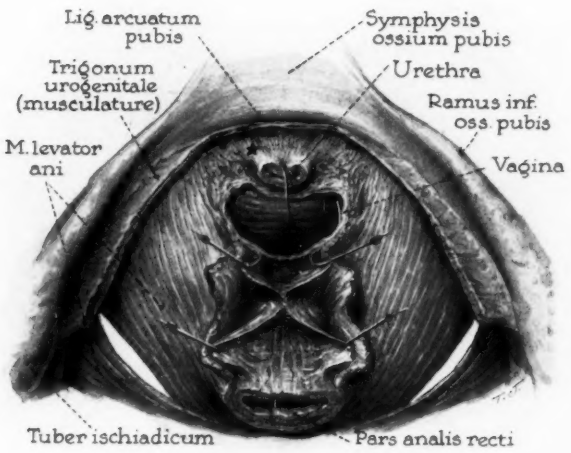

Fig. 13. The urogenital diaphragm has been removed except for a narrow strip of attachment along the ischiopubic rami and at the transverse ligament of the pelvis. Here are exposed the components of the clinically important "perineal wedge"; the pelvic diaphragm has been incised in the middle line from the anal to the vaginal canal. The relation of these canals to the pelvic diaphragm and to fascial sheaths which intervene between pelvic diaphragmatic and intrinsic layers of musculature is shown. Like the vagina and the anal part of the rectum, the urethra receives special fibers from the levator ani (see star).

firm attachment. In perineal view it may be seen that the fibers which reach the sides of the anal canal descend upon it, as if interrupted in their course; as they descend, their direction is slightly backward as well as toward the surface (Figs. 12 to 15). The fibers which reach the front of the canal likewise descend upon it, forming with the others a sleeve of definitely funnel-shaped character. More medially placed fibers, which, similarly, reach the vagina, terminate upon its sides, without, however, turning sharply inward (i.e., without changing course from sagittal to coronal plane); they fade away as they approach and interweave with the intrinsic muscle fibers of the vagina.

The intimate relationship of the pubococcygeus to the visceral tubes, and the direct support which this arrangement affords (Figs. 6, 13, to 15), are of fundamental importance in a proper understanding of the mechanics of plastic repair. Yet the operator should be aware that this muscle is in relation only with the terminal portions of the viscera; the support at a higher level is contributed largely by the fascial collars and related ligamentous structures. The latter statement applies particularly to the operative relief of cystocele and urethrocele; adequate rectocele repair requires not only the support of the rectovaginal fascial sheaths, but also restitution of the pubococcygeus together with the urogenital diaphragm.

Contrary to the usual gynecological concept, the chief part of the pelvic diaphragm is centered farther posteriorly than clinicians are accustomed to consider it. The bands of muscle fibers constituting the diaphragm are less massive anteriorly, in the urogenital region, becoming more dense and concentrated posteriorly where the fibers converge behind the rectum. The heavier nature of this so-called "levator plate" is ascribable to the fact that the fibers of the iliococcygeus course more transversely than do the fibers of the pubococcygeus; therefore, as the two subdivisions of the levator ani approach the coccyx, there is a double muscular banding where the iliococcygeus passes beneath the V-shaped vertebral extension of the pubococcygeus (Fig. 6; cf. Fig. 14). Nor is this all, since beneath the former, in turn, is situated the conjoined muscular plate consisting of the external anal sphincter and the coccygeal prolongation of the urogenital musculature (Figs. 9 to 11). The iliococcygeus is thus clasped be-

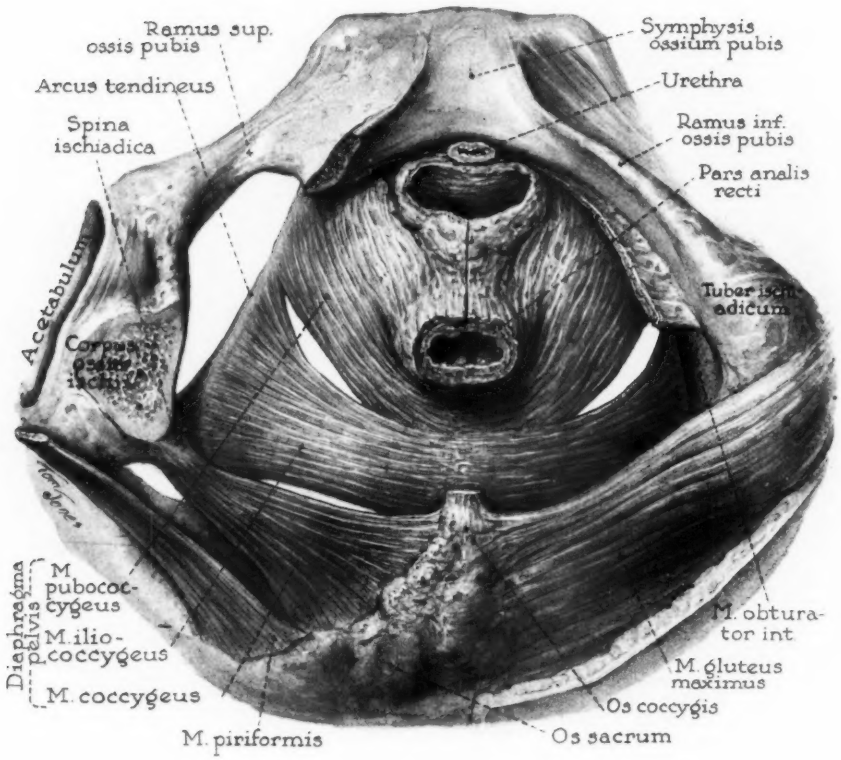

Fig. 14. Portions of the right innominate bone have been removed (cut through the inferior pubic ramus near the symphysis and the ischium superior to the level of the spine) to demonstrate the attachments, form and relationships of the pelvic diaphragm. The following features are especially important: the clefts between the adjacent muscular elements of the pelvic diaphragm; tendinous origin of the pubococcygeal and iliococcygeal divisions of the levator ani; the manner in which the pubic passes deep to the iliac division; the proximity of the urethra to the pubic symphysis, and the greater distance between vagina and anus; the complementary position which the coccygeus holds to the iliococcygeus (left), the manner in which it is covered by the gluteus maximus (right); the dorsal situation of the piriformis.

tween two musculoaponeurotic plates, each a dorsally directed appendage of a diaphragm; the superior one of the two (the pubococcygeus) supports the visceral tubes on their pelvic aspects (Fig. 6), the inferior (the so called urethral sphincter strengthened by the anal sphincter) contributing levatory support on the perineal side (Fig. 9).

This means that the area of the so-called "anococcygeal body" is one in which the constituent layers are readily separable, and in which indiscriminate surgery might destroy important supporting elements. Described usually in reference to the related portion of the colon, it is said that the levatores ani meet each other posteriorly in the anococcygeal body, "a fibromuscular body mingled with fat" and "placed between the anal canal and the tip of the coccyx" (Cunningham). Actually, as described above, this is not an area where tissues are mixed without semblance of physical plan; coccygeal insertions, arranged in laminar fashion, provide vertebral fixation for diaphragmatic and sphincteric musculature (Figs. 9 to 12).

The "perineal body" is likewise described in the standard accounts as an "indefinite mass" situated between the anal canal and the vagina. Its muscular constituents, however, are listed—they

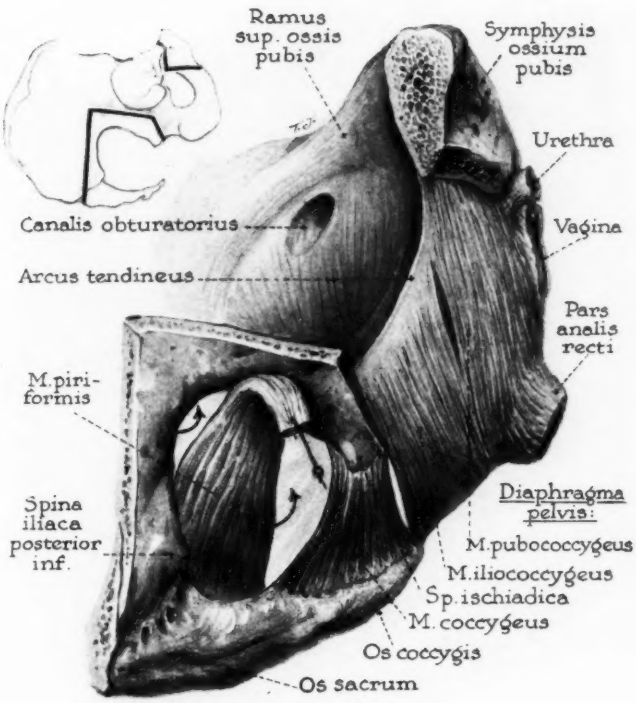

Fig. 15. Pelvic diaphragmatic and associated musculature. Lateral view. By cutting parasagitally through the superior pubic ramus and through the body of the ischium in front of the spine, and by then removing the bone between the pubic and ischial attachments of the levator ani (see inset), the following additional anatomical features, important in gynecology, are demonstrated: the arciform origin of the levator ani from the covering of the obturator internus (latter intact on specimen's left half); the uniformity in direction of the levator fibers; the position of the anal part of the rectum at the "spout" of the diaphragmatic "funnel"; the capaciousness of the foramina above and below the piriformis (at arrows); the relatively small size of the clefts between parts of the diaphragmatic musculature; the depth of the bony sciatic notch which is closed by the coccygeus and piriformis muscles.

being the anal levator and sphincter, the bulbocavernosus and transverse perineal muscles (cf. Figs. 9 to 11). The collection is said to be a wedge-shaped mass, the edge of which is directed upward, the base downward toward the skin. It is a matter of surgical consequence that the apical part of the wedge consists of the pubococcygeus muscle (Fig. 12), and, more deeply, of the fascial coverings of the anal and vaginal canals (Fig. 13). If this succession were not appreciated, repair of rectocele could not be properly managed nor dangerous instrumentation within the pelvic cellular tissues fully avoided.

The iliococcygeus has no direct relation to the organs as they pass from the pelvis to the exterior; even its most anterior fibers are removed from the anal canal by an appreciable distance; in crossing the midline in front of the coccyx, the muscle merely forms part of the floor and wall upon and against which the terminal part of the rectum rests. Similarly, of course, the iliococcygeus offers indirect support to the sigmoid colon and the jejunoileum, especially when the body is in the standing position. The iliococcygeus is of obstetrical importance as a support; it is of lesser interest in gynecological plastic operations. As

part of the pelvic diaphragm it is a factor in uterine support, and it is also important clinically in relation to disturbances in function of the sigmoid-rectum, which it supports to varying degree in different individuals.

The coccygeus is of subsidiary diaphragmatic service in helping to support the organs as they lie within the pelvic cavity and in passing, as a band-like barrier across the space between the coccyx and the ischial spine, it assists the levator ani (Figs. 7, 14, and 15). In pregnancy it furnishes a major support; but in labor, although subject to considerable strain, it forms only the posterior wall of the parturient canal and therefore suffers material injury only in pathological cases.

The coccygeus, piriformis, and obturator internus muscles assist the associated ligaments in maintaining the integrity of the sacroiliac joints, holding the posterior wall of the pelvis together; important anatomically as part of the pelvic framework, they are of gynecologic importance chiefly in relation to backache and sacroiliac sprain.

As mentioned above, the retropubic cleft transmits the dorsal vein of the clitoris (Fig. 6), and not infrequently an accessory clitoridal artery; this transmission brings into vascular communication, by an anterior route, the pelvic and perineal tissues. The sciatic foramina transmit the internal pudendal vessels (cut in Figs. 8 and 9) serving a comparable function posteriorly. There are, however, intermediate vascular connections of lesser importance; in specimen III, passing from the deep surface of the vestibular bulbs, they are carried through minute openings in the urogenital (Figs. 10 and 11) and in the pelvic diaphragms (Fig. 13); they are grouped around the anal canal, and occur only in that median area where the two diaphragms are in contact; they are not situated in a lateral position where their route would involve passage through an ischiorectal fossa. Whenever vessels are not confined to the two main pudendal routes (retropubic cleft and sciatic foramen), they are concentrated as accessories, in a median swath some two-fifths the width of the pelvic outlet. Curiously, vessels do not employ, in their perineopelvic passage, the clefts which separate the three subdivisions of the pelvic diaphragm (pubococcygeus, iliococcygeus, and coccygeus muscles).

SUMMARY AND DEDUCTIONS

The subcutaneous tissue of the labium is not an indiscriminate mass of fatty tissue through which pass scattered fascicles of dartos muscle. It is a definitely lamellated stratum in which is ledged a finger-shaped fatty diverticulum of the superficial inguinal fascia which is readily shelled out of its labial pocket. It is this process which produces the mound-like form of the greater lip. The posterior limit of the labial mound is coterminous with the bluntly pointed tip of the prolongation. The process rests upon the deep membranous layer of the superficial fascia. Within the tissue of its proximal portion, which begins at the subcutaneous orifice of the inguinal canal, not only is the round ligament dissectable, but also, in thinned form, successively, the labial extensions of the parietal layers of the abdomen.

Within the perineal compartment for which the deep membranous layer of fascia forms a firm floor, a much thinner but clearly defined layer, the inferior perineal fascia, covers the bulbocavernosus and ischiocavernosus muscles, the former again invested with a firm musculofascial sheath. In addition to the very definite individuality of its layers, another feature of the perineal fascia merits clinical as well as anatomical emphasis; the firm musculofascial sheath which overlies the bulbocavernosus muscle assumedly is that utilized in the operation of Martius, a procedure for relief of incontinence of urine in cases with destruction of the floor of the urethra.

Inability to palpate the normal Bartholin gland is not ascribable solely to its small size (Fig. 4); it lies hidden behind the fatty process at a considerably lower level than the infected gland, which is limited posteriorly by firm musculofascial tissues and therefore must extend anteriorly as it enlarges.

The proximity of the external anal sphincter to the cutaneous surface merits emphasis, as do also its wide trigonal and coccygeal attachments. In operative restitution of the sphincter, the firm anal and coccygeal extensions of the urogenital diaphragm and the pubococcygeal part of the pelvic diaphragm are important factors in the repair.

At the central tendinous point of the perineum the anal sphincter blends with the superficial transverse perineal muscle. The transverse perineal muscle, in turn, is blended with the underlying musculature of the urogenital diaphragm. The latter does not end at what is commonly considered the base of the urogenital diaphragm. Rather, it is prolonged to a coccygeal insertion, the urogenital diaphragm constituting, totally, a sling which utilizes not only pubis and ischium for fixation, but also the end of the vertebral column.

The musculature of the urogenital diaphragm is trilaminar. Strictly, it is the deepest of the three

laminae of the urogenital diaphragm that end on the coccyx; the intermediate one surrounds the anal canal, the most superficial merges chiefly with the walls of the vagina and the urethra and the anterior portion of the external anal sphincter.

We have been taught, catechetically, that the urogenital musculature crosses the midline between urethra and vagina, and between vagina and rectum, but that the pelvic diaphragm is deficient in relation to the visceral tubes, fibers supposedly sweeping backward behind the anal canal, to leave an elongate U-shaped cleft; but such a concept is entirely incorrect; fibers of the pubococcygeal part of the levator ani reach each of the three tubes—anal, vaginal, and urethral, and descend upon each to blend with the intrinsic muscular coat. The visceral support is so complete that even the urethra receives a full investment; no cleft is visible from the perineal aspect, even when the urethra is drawn away from the pubic symphysis.

It is the anterior or pubococcygeal division of the levator ani that affords continuous support for the organs of the urogenital and pelvic parts of the perineum; the iliococcygeus completes the diaphragm at the sides and behind, but does not come into contact with the viscera. It underlies the coccygeal extension of the pubococcygeus. This reduplication of muscle layers gives added firmness to the so called levator plate, that heavy portion of the levator ani situated behind the anus.

The preurethral cleft is small, oval in outline, little more than a retropubic hiatus for transmission of vessels and nerves from perineum to pelvis. Normally the urethra is close to the pubis —a fact of clinical importance in evaluating lesions associated with incontinence of urine. The urethra is displaced from the pubis by a traumatic labor, the pubococcygeal anchorage to the pubis being thereby disturbed. It is this preurethral cleft anteriorly and the sciatic foramina posteriorly that transmit almost all of the important blood vessels from one side of the pelvic diaphragm to the other.

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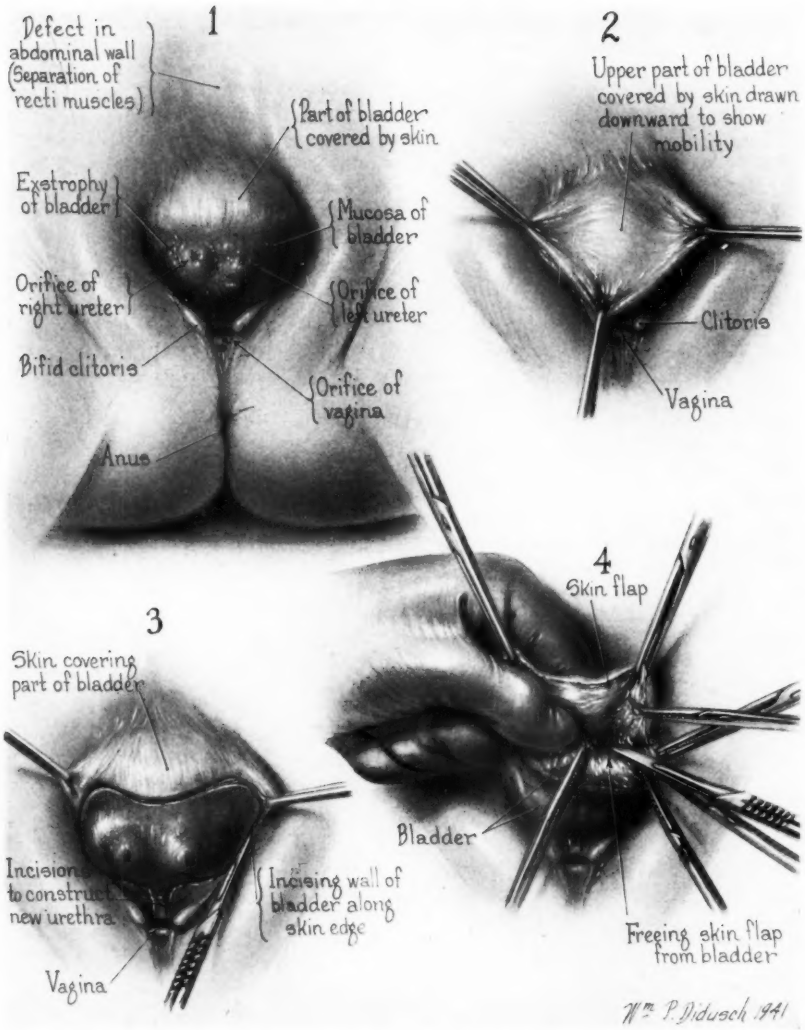


Fig. 3. Condition present at beginning of operation. Skin had grown down over upper half of bladder. This was used for flap which greatly facilitated covering wound. Inset 3 shows line of incisions and the strip of mucous membrane which provided tissue to form the urethra. Details are shown of technique by which excess skin and mucous membrane around vesical neck and urethra were excised, and then urethra formed, bladder closed after insertion of U shaped drain which emerged below.

EXSTROPHY OF THE BLADDER

The First Case in Which a Normal Bladder and Urinary Control Have Been Obtained by Plastic Operations

HUGH H. YOUNG, M.D., F.A.C.S., Baltimore, Maryland

OF ALL genital abnormalities, exstrophy of the bladder is certainly one of the most terrible. Until the recent present no operator has, I believe, ever obtained a complete cure in exstrophy. The great Trendelenburg spent his life trying to get a perfect result in these poor children and shortly before his death, in a very frank and pathetic article, he detailed the many variations of technique that he had employed without a single perfect result. He believed that it was necessary to disarticulate the pelvic bones at the sacroiliac synchondrosis so as to bring the widely separated pubic bones together in order to get a satisfactory urethra with sphincteric control, but even though he carried out this osteoplastic technique and succeeded in turning in the exstrophic bladder he failed to get urinary control in a single case.

I too have been working on this subject many years and although on the verge of success several times, some complication has always occurred to prevent a complete cure of the exstrophy with perfect urinary control and interval urination. After a series of these heart-breaking failures I am glad to be able to report a complete success in a case of extensive exstrophy of the bladder in a girl of 6 years in whom, by a technique that I have gradually developed, I have finally succeeded in obtaining the cure of this awful affliction that has been sought for by surgeons the world over for many, many years.

From the James Buchanan Brady Urological Institute, Johns Hopkins Hospital.

Fig. 1. Photograph of patient at age of 4½ years. Exstrophied bladder is 2 inches in diameter.

CASE REPORT

Extensive exstrophy of the bladder with 4 inch separation of the pubic bones. Cure of exstrophy at first operation; urinary control obtained by urethral and muscle plastic at second operation.

L. T., a girl aged 4 years, was admitted to the Brady Urological Institute on June 15, 1939 with congenital exstrophy of the bladder. Her faithful mother, by dint of great care and cleanliness, prevented inflammatory complications, but the large extruded mass and the constant escape of urine into the child's clothes made life unbearable. Otherwise the child had developed well and enjoyed excellent health. The condition present is shown in Figure 1. On the surface of the exstrophied bladder two cone-like projections were present and from them urine spurted on each side. A roentgenogram showed wide separation of the

Fig. 2. Plain x-ray film showing wide separation of pubic bones (10 cm.). Outlines of round exstrophied mass are shown.

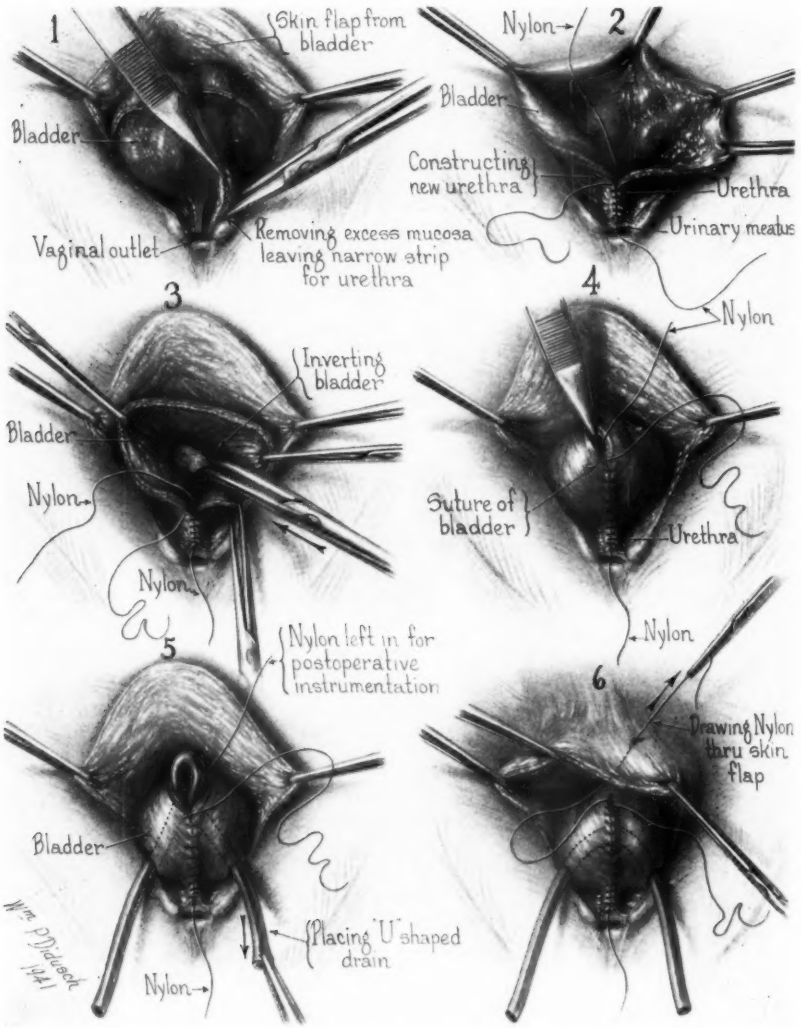


Fig. 4. Plastic to form a urethra, replace bladder within abdomen, and close it after supplying U shaped catheter drains.

pubic bones with a ligament connecting them. On this lay the wide open urethra. The mother was instructed to redouble her efforts to prevent inflammatory changes in the exstrophied mucosa and to return with the child in a year for operation.

On July 2, 1940, the patient returned. With the child standing the exstrophy presented a large almost globular mass which had increased in size and projected 2 inches from the surrounding abdomen. In the recumbent position the exstrophied bladder measured 2 inches in diameter. The ureters were seen as bulging prominences on each side of the lower third. The upper half of the exstrophied mass was covered by epidermis. The covering of the rest of the bladder looked like normal mucous membrane. The line of demarcation between the skin and the mucosa was sharp. The urethra was wide open and contained a central ridge. The orifice of a duct, probably Bartholin's, was visible on the left side. The clitoris was divided and presented a rounded mass on each side (Fig. 1). The orifice of the vagina was a small transverse slit. The perineum and anus appeared normal. The exstrophied mass was easily pushed with a finger back through an opening in the abdominal

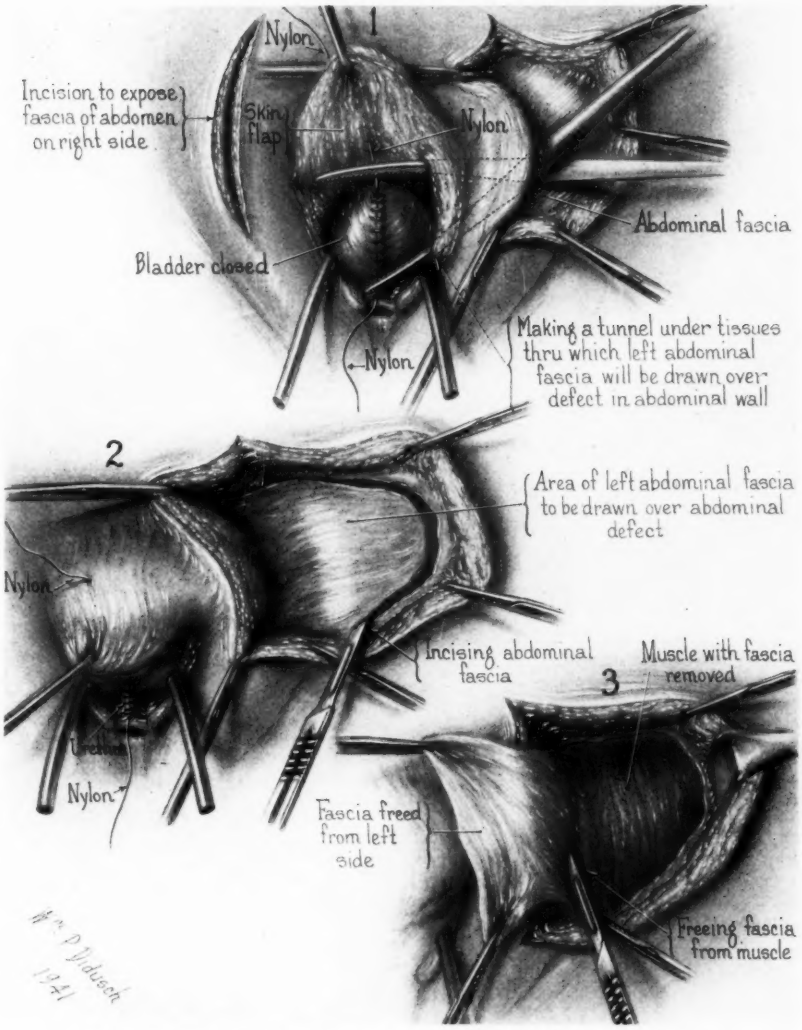


Fig. 5. Technique employed in obtaining fascial transplants from abdomen.

wall which had solid firm edges. External to these the widely separated recti muscles ran downward and outward to join the separated pubes. With the exception of the central defect the abdominal musculature appeared normal. Streams of urine escaped intermittently from the ureters. Urine collected from both sides was pale, of low specific gravity, and free from infection. General physical examination was negative.

A plain x-ray negative (Fig. 2) showed a 10 centimeter separation of the two halves of the pubes. The globular exstrophied mass was plainly shown.

Mr. Didusch's drawings depict the condition and the operative technique accurately.

In Figure 3, 1, the skin which covers the upper half of the exstrophy is shown and below it the orifices of the ureters, the wide open urethra, the separated halves of the clitoris, and the orifice of the vagina. In Figure 3, 2, clips placed on the skin, at its juncture with the vesical mucosa demonstrate, by traction, that this skin can be used to cover the wound at operation. The incision crossed at the junction of the skin and mucosa and then continued around the exstro-

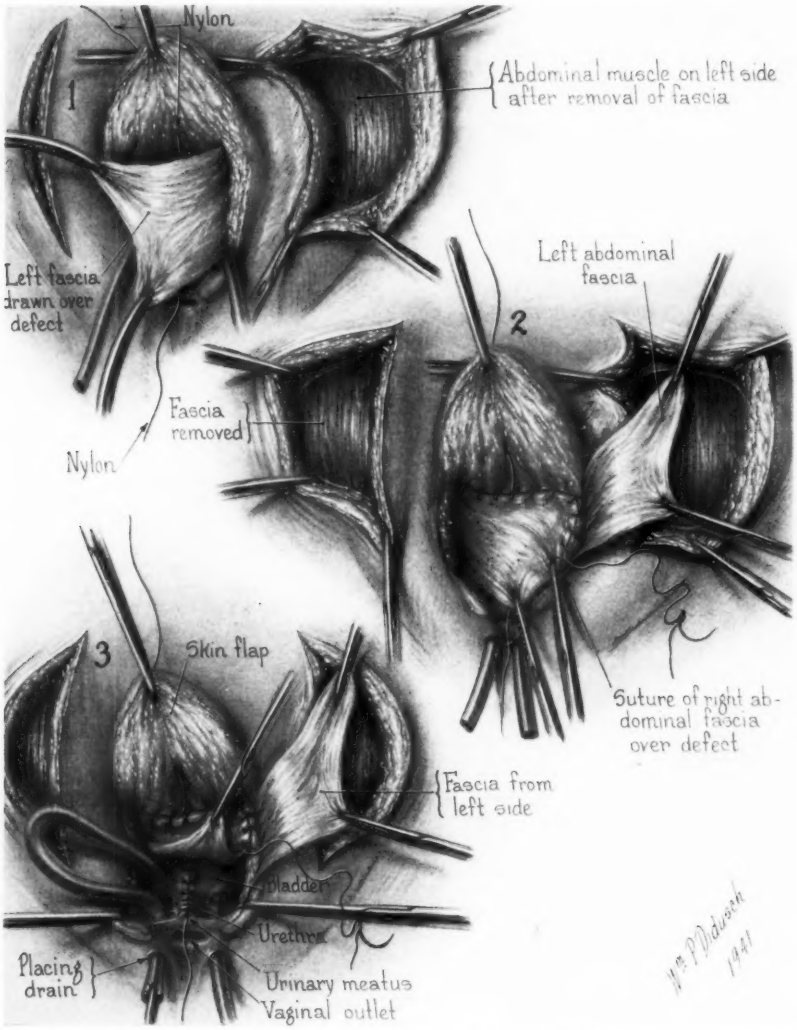


Fig. 6. Further details of fascial transplantation. To insure strength fascia from both sides was employed.

phied bladder and down below to form a new urethra (Fig. 3, 3). In Figure 3, 4, the skin flap is being dissected from the bladder muscle. Figure 4, 1, shows the excision of mucosa on each side of the urethral flap, thus disclosing muscle to be used in forming a sphincter. In Figure 4, 2, the edges of the mucosa are approximated with a continuous No. 0000 chromic catgut suture, a thread of nylon being left in the new made urethra as a subsequent conductor. In Figure 4, 3, the bladder is pushed through the abdominal defect preparatory to approximating the sides of the bladder wall (Fig. 4, 4). Drainage is provided with a rubber tube which, in the form of a U, emerges from the bladder on each side (Fig. 4, 5). In Figure 4, 6, the bladder closure has been completed, and the nylon is brought out through a puncture of the skin flap. Having closed the urethra and bladder,

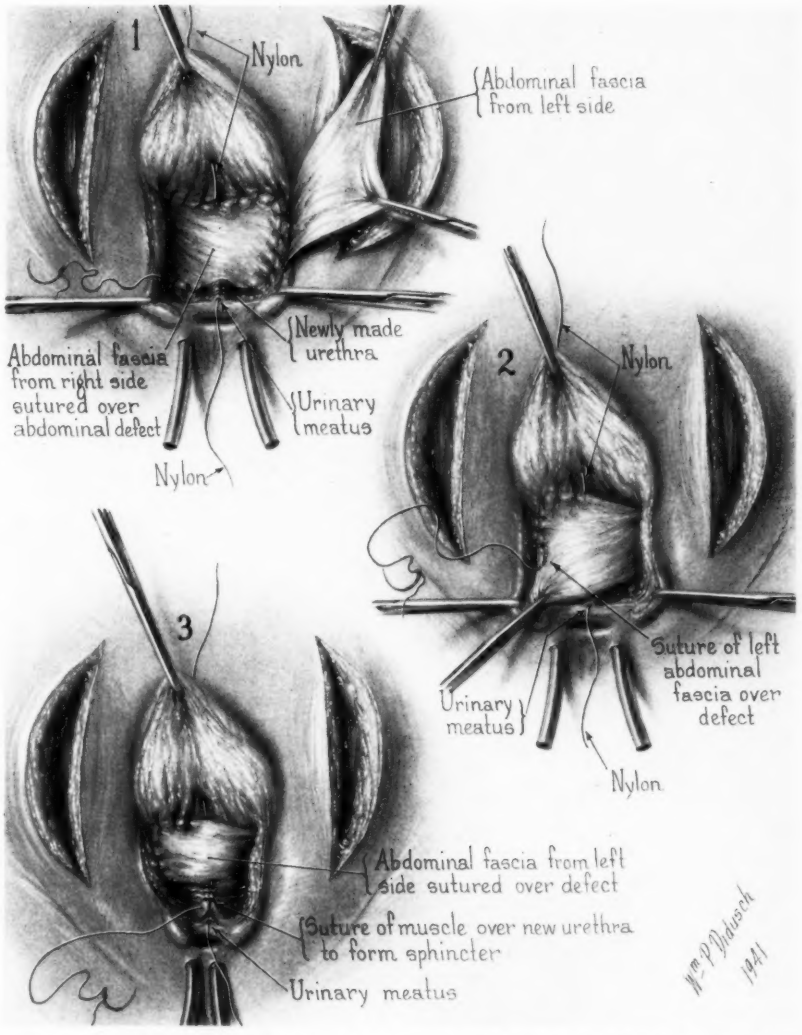


Fig. 7. Suture of fascial transplants completed (insets 1, 2) after which U shaped tubes had been drawn out along side of thigh for vesical drainage. Inset 3, Muscle drawn over new made urethra.

the next step provides fascia to close the defect between the recti muscles. This technique is shown in Figure 5. In 1 the incisions are made on each side to expose the abdominal fascia. On the left side the wound has been retracted, thus exposing abdominal fascia which is freed from superimposed skin and subcutaneous tissues along the side of the exstrophy. A tunnel is made here and is enlarged by spreading a clamp, as shown. The incision is made through the fascia as shown in Figure 5, 2. By blunt and sharp dissection the fascia is separated from the overlying abdominal muscles (Fig. 5, 3) up to the edge of the abdominal defect. In Figure 6, 1, this strip of fascia has been drawn through the opening over the inverted bladder. On examination it seemed that this strip of fascia was hardly large enough in itself, and it was decided to obtain another similar

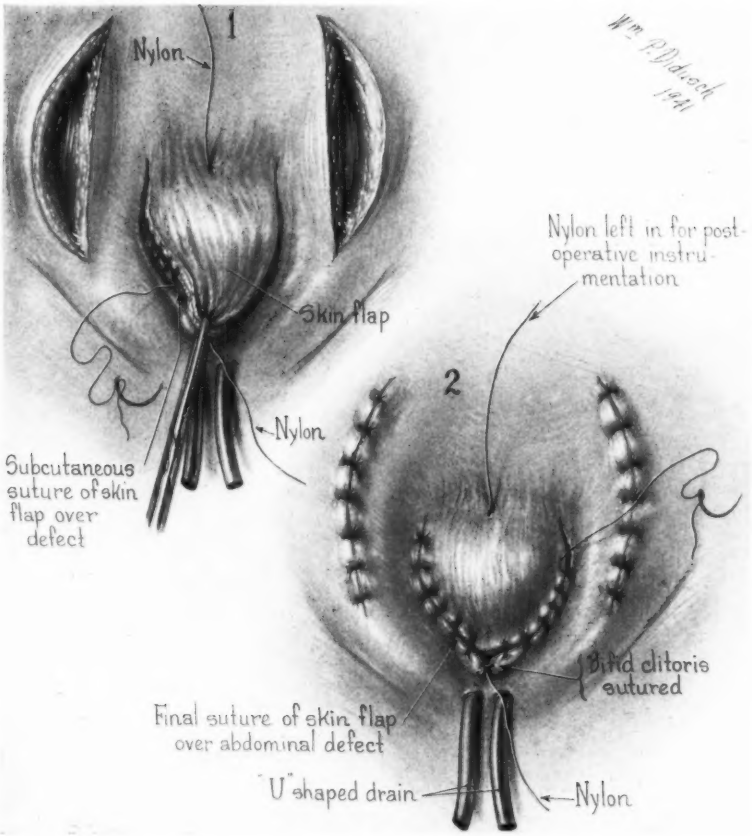


Fig. 8. Covering of deep plastic procedures upon bladder and urethra with an oval flap of skin which previously was dissected from upper half of bladder.

Fig. 9. Appearance on return of patient 6 months later. Exstrophy cured. Patient voiding through urethra but urinary control imperfect; partial incontinence.

strip from the right side as shown in Figure 6, 2, in which the fascia has been drawn across and sutured to the edges of the abdominal defect, thus completely covering the bladder. Before the lower stitches are placed the U shaped catheter, which has been inserted into the bladder for drainage, is carried beneath the pubic ligament and skin, on each side of the vagina, so as to emerge through the skin of the upper part of the thigh, as shown in Figure 6, 3. In Figure 7, 1, suturing of the abdominal fascia from the right side is completed. The left is held ready to be applied over it, as shown in Figure 7, 2. The next step is to cover the new made urethra with muscle drawn from each side. The technique is shown in Figure 7, 3. The orifice of the urethra, with the fascia above it, and the two rubber drains emerging from the wounds of the thighs are depicted. The oval skin flap, which has been dissected from

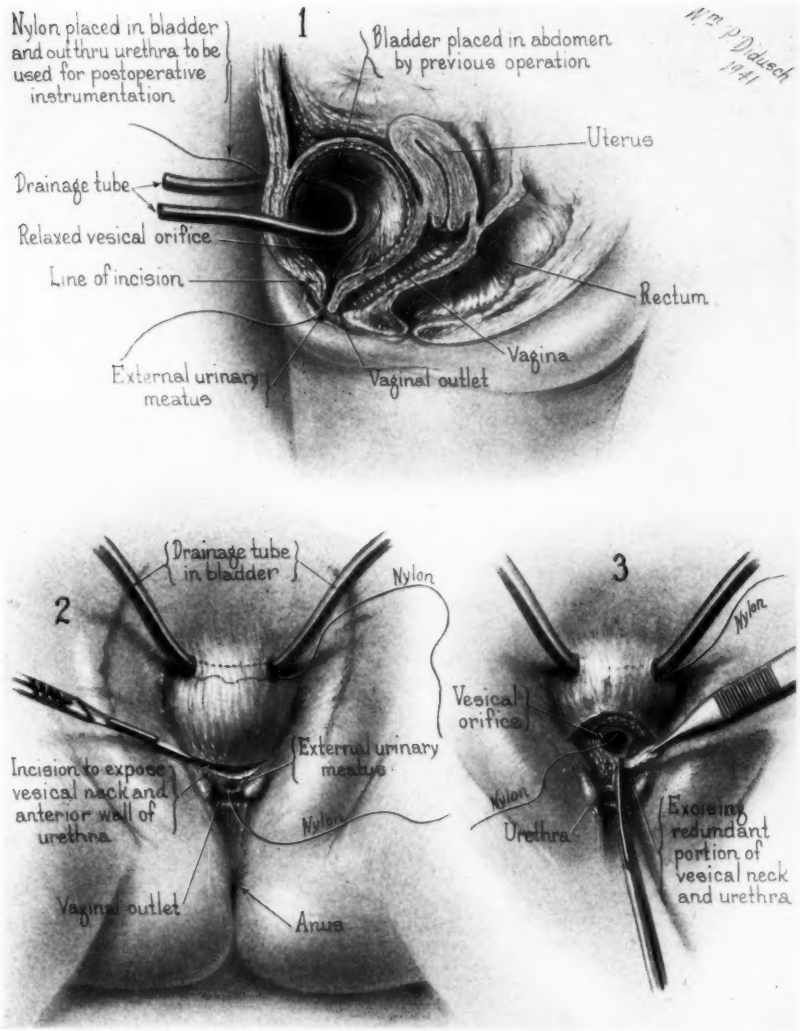


Fig. 10. Technique employed to resect urethra previously made and cure incontinence. A U shaped suprapubic catheter tube drainage was provided. Urethra was opened and a strip removed on each side, thus leaving very narrow tract from which to form a new urethra (3).

the bladder, is held upward on a clamp. The thread of nylon is seen where it enters the under surface of this flap. In Figure 8 the completion of the operation is shown. In Figure 8, 1, the placing of a subcutaneous stitch of fine catgut to anchor the oval skin flap is shown. In Figure 8, 2, the interrupted sutures of silver wire have been placed to close the wounds.

The patient stood the operation well; the anesthesia was perfect. Convalescence was satisfactory.

August 15, 1940. It is now 6 weeks since operation. The two ends of the U shaped vesical drainage tube emerge from the openings on each side of the vagina. The wounds have healed *per primam*. A No. 6 F. children's sound passes through the new made urethra into the bladder for a distance of about 6 centimeters. A small child's cystoscope also passes without difficulty. The tubes are removed.

August 17. The patient was discharged today. The urine escaped through the openings made for drainage. No urine escaped through the urethra.

The patient returned December 10, 1940. The conditions present are shown in Figure 9. As seen here the exstrophy had not recurred. The abdominal wounds presented a slight keloid effect. The two halves of the clitoris had separated. The urethra was small but incontinent. Examination seemed to indicate that not enough muscle

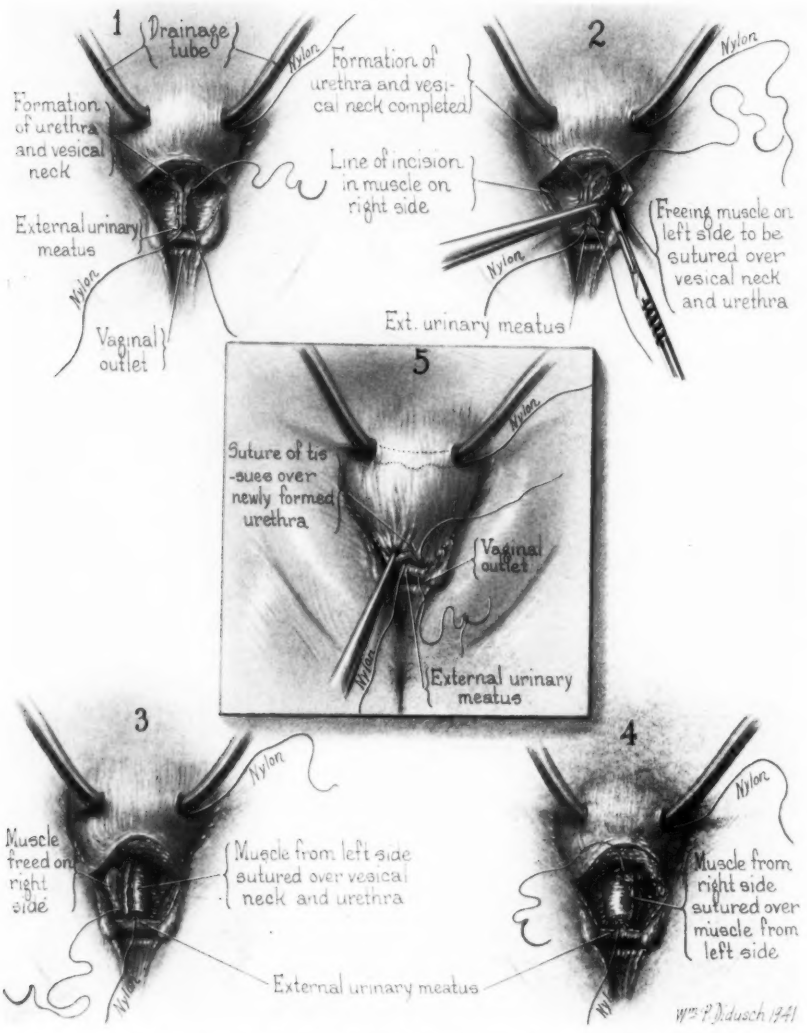


Fig. 11. Urethral closure completed and muscle flaps drawn from each side to cover it, after which skin edges were approximated with silver wire, leaving a strand of nylon in urethra.

covers it to give sphincteric control. It was decided to operate upon the patient again to obtain more and better muscle with which to surround the urethra.

On December 20 the second operation was carried out. The contracted orifice of the vagina was enlarged by an incision on each side. A goose neck clamp was introduced through the urethra and brought up against the anterior wall of the bladder for a distance of about 7 centimeters from the urethra. An incision was made through the tissues, skin, and bladder which were held up on its beak, which was then pushed out through the wound. A No. 16 rubber catheter was then drawn into the bladder and out through the urethra. A goose neck clamp was introduced by the side of the catheter and directed against the left anterolateral wall of the bladder. An incision was made on it at a distance of about 3 centimeters from the

opening which contained the catheter on the opposite side. A clamp passed in the opposite direction through this opening was made to emerge from the urethra where the tube was grasped and drawn back through the opening, as shown in Figure 10, 1 and 2. In this way good drainage was provided for at a distance from the region to be operated upon. In Figure 10, 2, is shown the incision which was made just above the orifice of the previously made urethra. This was enlarged (Fig. 10, 3) and after the urethra was opened it was found that too much skin had been used to form the urethra at the previous operation. A strip was excised from each side (Fig. 10, 3), thus leaving a very narrow strip of skin (only 3 or 4 mm. in width), in the median line posteriorly, and exposing muscle on each side. The technique of closure is shown in Figure 11. In first inset, the greatly resected urethra has been turned in with a continuous subcuticular No. 0000 chromic catgut suture on a Dulox needle. This line of suture was continued upward so as to close the bladder opening (Fig. 11, 2). It was decided to go at a distance of the median line to free muscle which could be drawn over the new made tight urethra on each side. In Figure 11, 2, the muscle flap, which was obtained on the left side is shown and in Figure 11, 3, the sutures, which were inserted to draw this flap over the new made urethra, are shown. Here also is shown a muscle flap which has been freed by an incision preparatory to covering the first muscle layer. Suturing of this layer of muscle is shown in Figure 11, 4; No. 0000 chromic catgut was again employed. As seen here, the newly made tight urethra was covered by two layers of muscle, one drawn from the left, the other from the right. After this it was necessary only to draw down from above the skin flap, which was quite loose and redundant, and to suture the skin and subcutaneous tissue to the adjacent wounds below with fine silver wire. Thus the muscle plastic was completely covered around the very tight urethra which contained only a strand of nylon to be used subsequently as a conductor for the passage of instruments.

Sulfathiazole, 1.5 grams, three times a day, was given the patient, beginning 2 days before operation and continued. Three days after operation the patient had a skin rash which was diagnosed scarlet fever. The patient was transferred to the isolation ward for 3 weeks. (It seems probable now that this was a sulfathiazole rash and not scarlet fever.)

The catheter, which emerged from the two cystotomy wounds in the upper part of the bladder, worked well, and no urine escaped through the newly tightened urethra. The sutured wounds healed *per primam* and the double drainage tube was removed on January 12. Two days later filiforms and a No. 14 children's sound were passed through the newly made urethra into the bladder, and a No. 12 urethral catheter was inserted for drainage to facilitate closure of the two suprapubic wounds.

Fig. 12. Motion picture camera obtained picture of the patient voiding. This is one of the frames. She was able to start and stop the outflow of urine on command and had complete control. Interval between voidings 2¼ hours.

On January 31 the suprapubic wounds having healed, the urethral catheter was removed. The patient voided at intervals through the urethra and with almost perfect control when she left for home on February 6.

For a time leakage occurred from a pin-point fistula high up in the skin flap where the strand of nylon emerged. This now has healed, and the patient is voiding naturally through the new made urethra. Urinary control is perfect, the interval from 1 to 2 hours. On July 8 the patient voided about 35 cubic centimeters of urine at a time. She has good control. A motion picture was taken of the child urinating. One of these frames has been enlarged to show this (Fig. 12).

July 28. By waking the child at 2-hour intervals at night, voluntary voiding was obtained and bed wetting avoided. The bladder gradually is increasing in size, and the patient is learning to hold urine longer. There is every prospect of a perfect result. She already has good urinary control, voids freely in a small but forcible stream, can stop and start the outflow on order when told to do so. The exstrophy was cured by the first operation; the incontinence by the second.

January 11, 1942 (letter). The patient voids urine at intervals of 3 hours with good control.

This is the story of apparently the first case of exstrophy of the bladder and incontinence that has been cured (B. U. I. 28229). After struggling with these cases for many years, this successful result tempts one to cry, "eureka."

SURGICAL AND POSTOPERATIVE TREATMENT OF LARGE VESICOVAGINAL AND RECTOVAGINAL FISTULAS

VIRGIL S. COUNSELLER, M.D., F.A.C.S., Rochester, Minnesota

IT is now nearly 100 years since the classic work of Marion Sims on vesicovaginal fistulas. He contributed more to this subject and brought about greater success in the treatment of the condition than any other person had done prior to 1852. Since then there have been numerous modifications and suggestions as to surgical technique and methods of approach to the fistula. The same is true of fistulas from the bowel to the vagina. The problems involved in the treatment of these fistulas are as difficult as, and are often greater than, the problem of treatment of vesical fistulas. When both vesicovaginal and rectovaginal fistulas exist simultaneously, the problems involved in the surgical and postoperative treatment are considerably increased.

It is not my intention to review the various causes of these fistulas, with which all are so familiar; instead, I wish to point out some of the pitfalls in surgical management which frequently predispose to recurrence of the condition; I also wish to emphasize the importance of meticulous postoperative care for both vesical and rectal fistulas into the vagina, especially those of the larger and more complicated types.

VESICOVAGINAL FISTULA

It is the experience of most surgeons that in about 85 per cent of cases most small vesicovaginal fistulas can be closed at one surgical procedure, especially if previous repeated attempts at closure have not been made. Small vesical fistulas do not often constitute a difficult problem. However, I feel that it should be emphasized seriously that small fistulas such as these occasionally can resist all the skill of an expert surgeon, principally because enough attention has not been given, first, to the situation of the fistula and, second, to residual infection which may be present in the bladder. The importance of the situation of a vesical fistula cannot be too greatly stressed. For example, a small fistula which involves the posterior margin of the internal vesical sphincter is one of the most difficult to close of all fistulas within my experience, and it should not be considered lightly. Since the fistula involves the sphincter, the sphincter is, therefore, torn and partially incontinent, resulting from contraction and formation of scar tissue within the circular muscle fibers. It is most difficult to avoid superimposing the vaginal and vesical suture lines at this point without producing distortion of the sphincter and urethra. Apposition of these suture lines predisposes to recurrence. Furthermore, when a catheter is placed through the urethra into the bladder it is almost sure to lie in contact with the region of repair, and such contact is a very potent factor in recurrence. The catheter always produces irritation and also incites infection, which induces breakdown of the suture lines. This factor is one of the chief difficulties in closure of urethral and urethrovaginal fistulas. Urologists who now have become familiar with this fact do not leave a catheter in the male urethra subsequent to surgical repair of urethral fistula or after performance of plastic procedures for hypospadias. The patient is encouraged to arise and micturate in the normal manner, or, if the surgical procedure has been too extensive, a perineal opening is made in the posterior urethra to divert the urinary stream. I am beginning to believe, however, that if a patient can void, the passage of urine over a small repair in the urethra or sphincter is more beneficial than detrimental, since by such a flow all sediment and exudate periodically are lavaged from the suture line. This belief, however, does not apply to fistulas situated entirely within the base or vault of the bladder, where they are constantly bathed in urine.

The second factor of residual infection within the bladder in the failure of these small vesicovaginal fistulas to heal is one which is even more serious when large fistulas are encountered, and must be evaluated carefully before operation: a bladder that becomes totally incontinent becomes contracted and infected. Infection in such instances does not produce subjective symptoms, since the irritation cannot induce the desire to void, and the situation becomes annoying to the patient only if the upper part of the urinary tract becomes involved. Irritation and incrustation within the vagina constitute sufficient evidence that the same processes probably prevail within the blad-

From the Division of Surgery, Mayo Clinic.

Read before the meeting of the Louisiana Gynecological and Obstetrical Society, Shreveport, Louisiana, April 21, 1941.

der, and the conditions usually are induced by urea-splitting organisms, primarily those of the Proteus group, which are the most common and unfortunately the most difficult to eradicate. The formation of incrustations on the mucosa in the region of repair is an extremely potent factor in predisposition of the fistula to recurrence. The factors which are operative in the healing of wounds are exactly the same in this particular situation as they are elsewhere; namely, freedom from infection, proper hemostasis and lack of tension, so that interference with blood supply does not occur.

Large vesicovaginal fistulas of several months' duration constitute the greatest surgical problem from the standpoint of causation, infection and contraction of the bladder, retraction and scarred vaginal and vesical mucosa, involvement of the trigon, ureters, and sphincter. Destruction of the vesical neck, sphincter, and a portion of the urethra often brings about what approaches a hopeless situation in the matter of restoration of vesical function (Fig. 1). Such a situation usually is directly attributable to difficult and perhaps faultily performed obstetrical procedures and to the results of radiation therapy for carcinoma of the cervix. In the first instance the earlier surgical repair is undertaken, the greater will be the chances for cure. A patient who has this type of lesion is always entitled to one or two serious attempts at repair, but any further effort is not likely to be successful. The principal effort must be directed, first, toward complete excision of all scar tissue and, second, toward complete mobilization of that portion of the bladder which is involved. This may be a difficult task, since the bladder often appears to be "frozen" against the pubic rami from which it must be entirely separated. The lacerated vesical sphincter retracts exactly as the lacerated rectal sphincter retracts and, therefore, it becomes essential for the surgeon to loosen the fixed residual portion to enable him to reapproximate the circular fibers of the sphincter. Since the trigon usually is almost wholly destroyed, it becomes necessary to narrow the trigon by bringing the ureteral orifices toward the midline. In extensive repairs of this type sufficient vaginal mucosa may not be available for the purpose of complete coverage of the denuded region. If the wall of the bladder will remain closed, the vaginal mucosa will eventually epithelize over the region. Absence of the urethra is not particularly important. If the sphincter can be made to function, so that complete continence results, a urethra can be constructed at a later date, if necessary. Several of my patients have

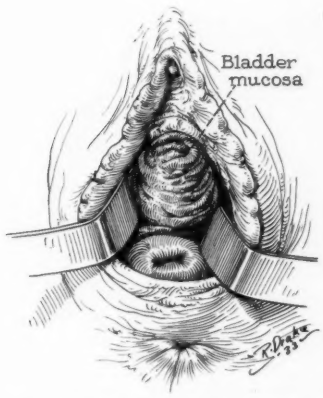


Fig. 1. Destruction of the bladder neck, sphincter and portion of the urethra (after Stephenson, G. W., and Masson, J. C. Surg., Gynec. & Obst., 1934, 58: 1036–1039).

complete urinary control and yet have a very short urethra; they do not have an external urethral sphincter. When reconstruction of the vesical neck is deemed a surgical impossibility, or if failure ensues subsequent to repeated attempts at repair, I think that diversion of the urine to the bowel is the procedure of choice.

A large vesicovaginal fistula which occurs after extensive radium therapy for carcinoma of the cervix is still less likely to be successfully repaired, by virtue of the fact that the tissue at a considerable distance from the edge of the fistula usually is too devitalized to be suitable for repair, and it is often impossible to mobilize this tissue. Any attempt at surgical repair necessarily must be delayed a sufficient length of time to preclude the possibility of local recurrence of the malignant process. Later, when there is no evidence of a residual malignant process, I believe that the patient is best treated by bilateral ureterosigmoidostomy.

Methods of approach. A well planned procedure should be outlined for each patient who has a vesicovaginal fistula. The fistula may be approached vaginally, transvesically, or transperitoneally. Ureterosigmoidostomy also will be considered herein.

Vaginal approach. The result from each of the aforementioned methods may be highly successful, but it is generally agreed now that the method of vaginal approach has many advantages over the others and that the operative risk which accompanies this method is practically nil. During the year 1939, 32 vesicovaginal fistulas were repaired surgically at the clinic, and all were re-

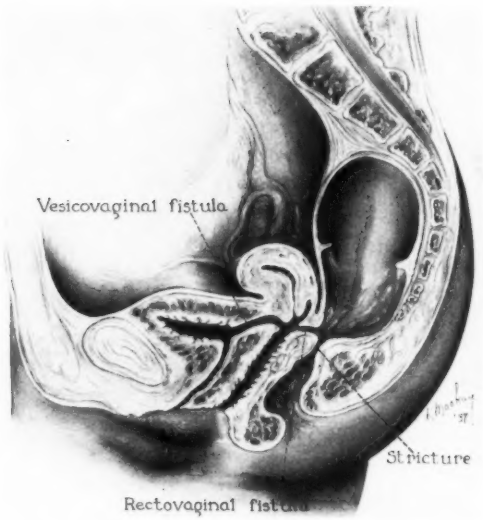


Fig. 2. Illustration of a vesicovaginal and rectovaginal fistula which was situated high in the vagina (after S. B. Lovelady and J. C. Masson. Proceedings of the Staff Meetings of the Mayo Clinic, 1938, 12: 49–53).

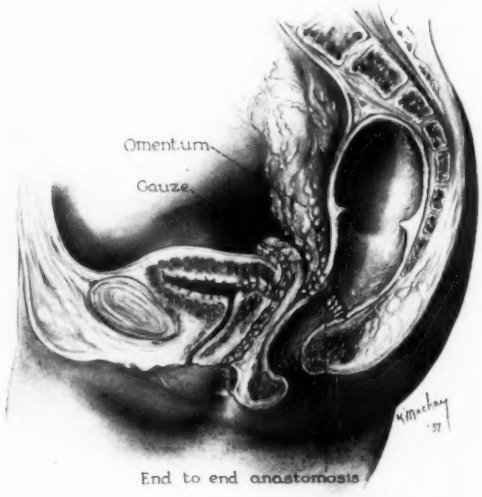


Fig. 3. Performance of hysterectomy and closure of both fistulas from the abdominal side. Portion of the bowel was excised and end-to-end anastomosis was done. Gauze draining the cul-de-sac is in position (after Lovelady and Masson, loc. cit.).

paired by the vaginal approach. At the clinic we prefer to have the patient in a modified Kraske position, with the thighs well separated and the terminal portion of the operating table removed. A Sims speculum is held firmly against the perineum and posterior vaginal wall, which permits easy exposure of the entire wall of the bladder and urethra, except perhaps in the nullipara in whom a fistula has occurred subsequent to total hysterectomy. In such an event a Schuchardt's incision is made which converts the vaginal canal into a wide open cavity. The advantages of this approach are obvious. It permits the surgeon to dissect directly on the lesion rather than through a dependent cavity, as is necessary in the transvesical approach. The ureters can be catheterized with ease, if it is advisable to do so, when a laceration has extended laterally to the ureteral orifice. The ramifications of the tear in the wall of the bladder can be more nearly accurately identified. Fistulas that arise after total hysterectomy are most favorably approached in this manner, since they are practically always situated high in the vaginal vault and result from passage of a suture through the wall of the bladder during closure of the vaginal vault. It is a relatively simple procedure to open the cul-de-sac above the fistulous opening, and by placing a finger into the peritoneal cavity, the bladder can be separated from the scar tissue and drawn forward into the vagina.

Transvesical approach. A transvesical approach is desired by many surgeons, perhaps because of a lack of familiarity with the pelvic anatomy, a familiarity which is essential. When this method is selected it must be predetermined that the repair will be entirely successful; otherwise the patient will have both a vesicovaginal fistula and a suprapubic fistula, with a contracted bladder. The problem then, of course, is greater than that which previously existed.

Transperitoneal approach. The transperitoneal approach entails a much higher risk than any other method and should be undertaken only in very select cases. A fistula that is situated high in the vaginal vault in an extensively scarred and fixed region (the scarification and fixation usually resulting from postoperative cellulitis) may be more adequately treated by this method. After exposure and closure of the fistula, it is advisable to interpose some fat, obtained either from the omentum or from the rectum between the wall of the bladder and the vaginal mucosa. The real danger which may arise when this method is employed is necrosis and leakage of urine, which is always infected, into the peritoneal cavity. It is wise to be prepared for this sequela by splitting

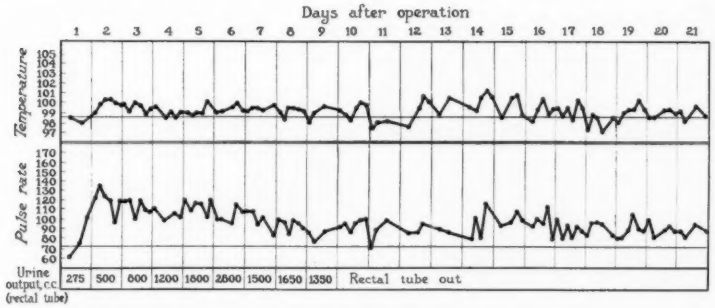


Fig. 4. Clinical course of a patient who underwent bilateral simultaneous ureterosigmoidostomy for carcinoma of the cervix. Note the urinary output.

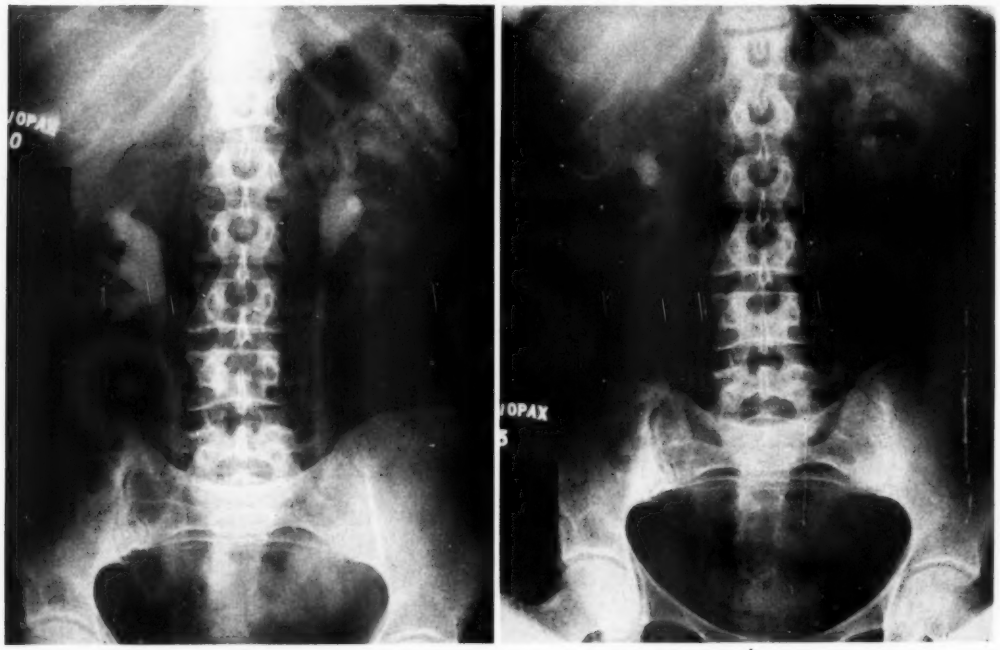
the posterior vaginal wall and establishing adequate drainage into the vagina from the cul-de-sac at the completion of the operation.

A positive indication for the transperitoneal approach is encountered in cases in which it is desirable to do hysterectomy in addition to closure of either a vesicovaginal or rectovaginal fistula, or both. In such cases a gauze drain always should be left in position in the vagina and cul-de-sac (Figs. 2 and 3).

Ureterosigmoidostomy. This procedure is used only occasionally in the treatment of large fistulas and it should be employed for those patients whose bladders have been rendered incapable of retaining urine. In the majority of cases, the condition develops subsequent to radium therapy for carcinoma of the cervix, or subsequent to repeated attempts at surgical repair which have resulted in extensive formation of scar tissue and a secondarily contracted bladder. The risk accompanying this operation, when the patient is in good general condition, does not exceed 5 per cent. At the clinic we formerly divided the operation into two stages, transplanting the right ureter first and transplanting the left ureter 2 weeks later, but during the past few years we have been accustomed to transplant both ureters simultaneously without increasing the mortality rate. The anastomosis usually performed is the Mayo-Coffey type. Perhaps the most important conditions necessary for success are a normal ureter, a clean bowel, and an anastomosis so conducted as to produce a minimum of obstruction. When there is very little obstruction, urine should appear in the rectum almost immediately. In a recent case of bilateral ureterosigmoidostomy performed for a huge vesicovaginal fistula that had developed after treatment for carcinoma of the cervix, urine appeared in the rectum shortly after the patient returned from the operating room, and increased normally during subsequent convalescence (Fig. 4). The excretory urogram will reveal any evidence of obstruction of the anastomosis (Fig. 5a and b).

Management of infection. A vesicovaginal fistula of long standing never exists without the development of infected urine, resulting in a vesical condition varying from mild cystitis to cystitis with incrustation and a contracted bladder. It is reasonable to assume, then, that a clear urine which is free from harmful bacteria should be a prerequisite to surgical repair of such a fistula, if primary wound healing is to be anticipated. A period of preoperative preparation is just as essential in operation for this lesion as it is in operations for many other lesions. Bacteria in the urine are numerous, but the predominating ones are those of the colon group and the pseudomonas group, and the Streptococcus faecalis and the Salmonella ammoniae. Specimens of the urine should be cultured routinely at the time of the cystoscopic examination, so that the type of predominating organism can be determined. Cystitis with incrustation or incrustation in the vagina suggests that a urea-splitting organism is present, and accordingly, treatment can be started immediately.

The introduction of sulfanilamide and its derivatives has been a decided asset in the management of lesions such as the ones under consideration. The rapidity with which the infection can be destroyed within a few days, and the fact that the patient can remain ambulatory are very remarkable. The patient usually receives from 1 to 2 grains (0.065 to 0.13 gm.) of sulfathiazole, daily, an amount which usually is sufficient to acidify the urine so that a hydrogen ion concentration of 5 to 5.5 is reached within a few days' time. If the Streptococcus faecalis persists or members of the Proteus group persist after repeated cultures, medication is best shifted to mandelic acid, which is administered four times a day as elixir of am-



a b

Fig. 5. Bilateral transplantation of the ureters to the sigmoid for carcinoma of the cervix; a, left, 5 minute roentgenogram, in which fairly good concentration is seen on right side and fair concentration is seen on the left side; b, 20 minute roentgenogram, in which good concentration is seen on both sides; ureterectasis, pyelectasis, and caliectasis, grade 2, on the right side and grade 1, on the left side, are present.

monium mandelate, in doses of 3 drachms (11.7 gm.). The intake of fluid is restricted to 1000 cubic centimeters in 24 hours. With the gradual decline in numbers of the organisms mentioned, and if the inflammation of the vagina and bladder is receding, surgical repair may be instituted safely, but medication and the making of cultures of the urine must be continued during convalescence of the patient. The advantages of a sterile urine in wound healing, in particular, during the postoperative course cannot be overestimated.

The appearance of calculi in the upper part of the urinary tract or within the folds of the mucosa of the bladder, is a potent cause of continued pyuria while medication is being continued. Surgical repair of large vesicovaginal fistulas is not advisable until all calculi are removed. The advantages of the making of an excretory urogram as a preoperative measure are obvious, for the urogram not only will disclose calculi but will also provide a fair index to renal function and will reveal evidence of previous infection in the upper portion of the urinary tract which might become a serious complicating factor during convalescence.

Postoperative care. There is no surgical procedure which requires more constant and special postoperative care than repair of a large vesicovaginal fistula. Attention must be directed toward the insuring of a continuous flow of urine through the catheter, especially after the eighth postoperative day, when suture material begins to show evidence of absorption. Should the catheter become occluded or partially extruded, sufficient pressure may accumulate to produce leakage. At the clinic we have attempted to fortify ourselves against occurrence of this accident by adoption of a routine in which every patient is placed on a Bradford frame in the prone position, about 18 inches or more (15 cm. or more) from the surface of the bed. A two way irrigating system is provided and the bladder is gently irrigated with a few cubic centimeters of solution of boric acid each hour during each 24 hour period. The urine is allowed to drop continually in a basin placed on top the bed, where it can be observed by both patient and nurse. An effort is made to isolate such patients on one floor, where student and special nurses are particularly instructed about nursing care.

As long as suture material of any type exists within the vagina, there will be a constant flow of exudate, which, if it is not removed daily, will macerate the tissues, an occurrence which will predispose to premature separation of the suture line. For this reason, the vagina is cleansed daily by the careful introduction of a Sims speculum along the rectal wall, to expose the suture line. All mucus, exudate, or blood is removed with a dry cotton sponge and the suture line is painted with a germicidal agent (tincture of merthiolate). This routine also permits the surgeon to observe the healing process.

Specimens of the urine for culture are taken daily directly from the catheter, the bacterial count is estimated, and the acidity is determined. The administration of sulfathiazole is continued during convalescence of the patient. If strict attention is given to this detail, incrustation will not occur on or within the catheter. Prior to institution of this routine at the clinic it was not uncommon for the catheter to become occluded with sediment.

Proper selection of an indwelling catheter contributes much to the comfort of the patient. The catheter employed should be one that does not rest on the trigon or produce pressure against the internal vesical sphincter muscle. To obviate these possibilities, I devised one which consists of a French catheter (male), size 18 or 20, which is introduced through a larger segment of soft rubber tubing about 4 to 6 inches (10 to 15 cm.) in length. Approximately 3 to 4 inches (8 to 10 cm.) of the soft rubber tube which forms the outer sheath is sectioned to produce four strips of rubber equal in length (Fig. 6). The French catheter is held firmly by the remaining segment of the outer soft rubber tube. The catheter is inserted through the urethra for the proper distance and the four strips of rubber are secured to sections of adhesive tape placed toward the pubes and also lateral to the rectum. The patient may move in any position, yet the catheter will remain in the original position, and the exertion of tension on the catheter is prevented.

The patient lies on the Bradford frame for a minimum of 2 weeks, depending on the character of the fistula which she had. After being removed from the frame, the patient remains in bed 2 to 3 days longer. The catheter is then removed and she is instructed to micturate every hour during the next 24 hours; then to micturate every 2 hours for 2 to 3 days, so as gradually to increase vesical function. At the time of dismissal, either the urine should be sterile or bacteriuria should be reduced to grade 1.

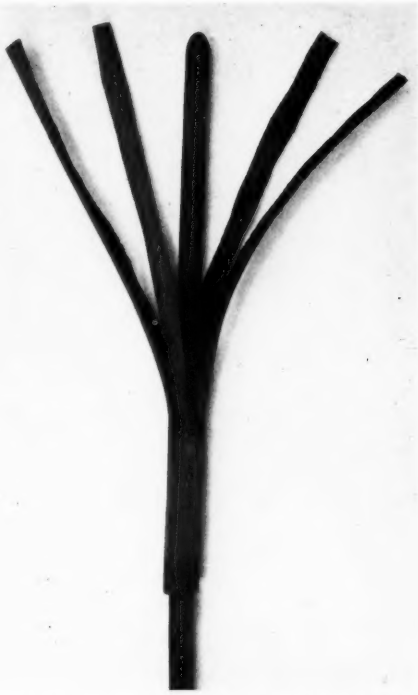


Fig. 6. A new method for retention of a nonirritating catheter in the female bladder.

RECTOVAGINAL FISTULA

There are three types of rectovaginal fistula which I wish briefly to discuss; namely, (1) that which occurs simultaneously with vesicovaginal fistula, (2) that which develops subsequent to repair of complete laceration of the perineum and (3) that which arises insidiously and in conjunction with an abscess in an anal crypt.

Rectovaginal fistula which develops with vesicovaginal fistula. As a general rule, this type of fistula is situated high in the vaginal wall, as exemplified by the fistula encountered subsequent to radium therapy for cancer of the cervix. This type of fistula occasionally is seen after precipitate labor in a previously nulliparous patient, and, in such instances, complete laceration of the perineum also is likely to have occurred.

Although it may be possible to repair both lesions (that is, vesicovaginal fistula and rectovaginal fistula) simultaneously, the risk of recurrence of either one or the other condition is most certainly considerably greater if such a procedure is carried out. When the vagina has been converted

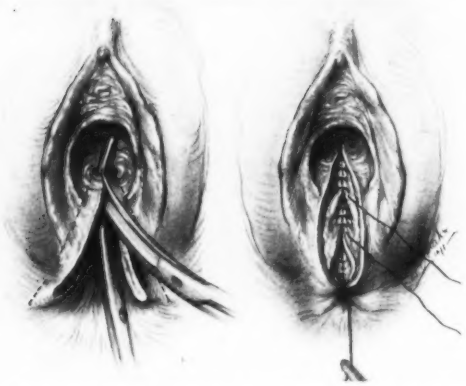


Fig. 7. a, Left, division of scarred perineum and scar and fistula excision; b, reconstruction of anterior rectal wall.

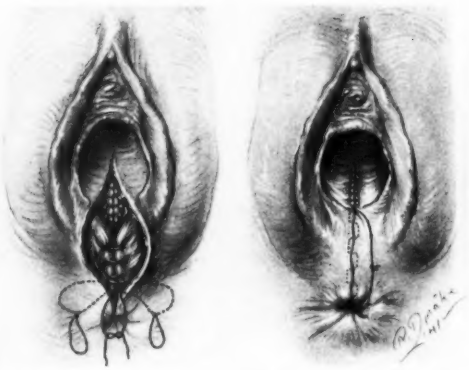


Fig. 8. a, Left, reconstruction of perineum and sphincters; b, method of suturing perineum.

into a cloaca, much residual infection nearly always remains in both the rectal and vaginal walls, and this infection too often becomes reactivated after surgical repair. The advantages of preliminary temporary colostomy to divert the contents of the bowel from the vagina should be stressed. Colostomy is not to be considered a routine procedure, but should be performed only when more extensive lesions are present and for patients of poor general condition. For example, a young patient came under my care several months prior to the time of this report, suffering from a large vesicovaginal fistula, complete laceration of the perineum, and a rectal wall that was torn completely up to the cervix and to the left lateral angle of the vaginal vault. The condition had occurred subsequent to precipitate labor. Extensive pelvic cellulitis with fixation was present, and the patient was greatly debilitated. The two fistulas were so situated that the contents of the bowel would be evacuated into the contracted bladder and then into the vagina. Preliminary colostomy was performed, and 3 weeks later, when the infection had subsided and the urine had become clear, the vesicovaginal fistula was repaired. Because of the cellulitis and fixation, the patient was sent home, to remain there for 4 months. At the end of that time cellulitis had subsided completely, menses had become normal, the rectovaginal tissues had become soft and pliable, and she had gained 20 pounds (9 kg.). The perineum, sphincter, and rectal wall were at this time in such good condition that reconstruction was easily possible. The colonic stoma was closed 4 months after the last operation for vaginal repair. At the time of this report the patient was entirely normal and it had not been necessary to repeat either surgical procedure.

Rectovaginal fistula incidental to complete perineal laceration. Many operations have been illustrated for repair of a rectovaginal fistula incidental to repair of complete laceration of the perineum, and most of such procedures have been found to have considerable value. In operations that are directed at excision and primary closure of the fistula or the reflection forward of a flap of vaginal wall, two extremely important factors are disregarded; namely, complete excision of all scar tissue (including the fistula) and reconstruction of the anterior wall of the rectal tube to its original length. These conditions are best satisfied in the treatment of rectovaginal fistula by complete division of any remaining portion of the perineum and rectal wall, a procedure which converts the fistula into the opened rectum as in complete laceration of the perineum (Fig. 7a and b). All scar tissue is completely excised to expose the ends of the sphincter ani muscle, levator ani muscle and the various layers of the rectal tube. Repair of the wall of the bowel is conducted in such an instance exactly the same as it would be done in an operation within the abdomen. Each layer must be repaired separately. After the bowel has been restored to its normal length, the perineum and sphincter are reconstructed (Fig. 8a and b).

Fistula that arises after infection in an anal crypt. This type of fistula is rare but nevertheless is seen sufficiently often to call attention to some important considerations in diagnosis and surgical treatment of the condition. The fistula usually originates as a fistula-in-ano. The fistula-in-ano may appear to heal spontaneously, but a firm

nodule will develop on the vaginal wall just behind the perineum, and will remain extremely tender and will finally periodically subside. Subsidence is considered to be due to evacuation of the contents of the abscess into the bowel. The patient appears to be entirely comfortable and free from disease for several weeks; then the nodule recurs on the vaginal side of the wall, with extreme tenderness and discomfort. Finally, the contents of the abscess rupture into the vagina, and fecal material and gas periodically will be discharged through the fistulous opening into the vagina. My reason for drawing attention to this lesion is the fact that attempted closure of this fistula before all the inflammatory process in the rectal wall has subsided will result in surgical failure in 100 per cent of cases. Furthermore, the small focus of infection in the anal crypt usually is only one part of the infectious process and there are ramifications in the form of fistulous tracts in the bowel wall that must be completely excised.

The proper form of attack on such a fistula, then, is a two stage procedure. The first procedure is the problem of the proctologist, and it is usually necessary to cut both sphincter muscles and to destroy completely the perineum. However, this is not true in every instance. When there is evidence that the inflammatory process has subsided and that complete or partial loss of control of the bowel has occurred, the problem becomes that of the gynecological surgeon: to reconstruct the anterior rectal wall and the perineum. In other words, the lesion is essentially the same at this particular stage as the lesion which is present at repair for complete laceration of the perineum, after all scar tissue has been completely excised.

Postoperative care. Postoperative care of patients who have undergone repair of rectovaginal fistulas is of importance equal to that of postoperative care for patients who have undergone repair of vesicovaginal fistulas. The operative incision must be inspected daily from the vaginal side and from the rectal side. For from 1 to 2 weeks the bowel should be prevented from moving. Exposure of the suture line within the rectum is accomplished by means of a small anoscope. All mucous secretions and flecks of feces should be removed daily through the anoscope, and the suture line within the bowel should be painted with a germicidal agent (merthiolate). A small Sims speculum is placed in the vagina and the anterior vesical and vaginal walls are held firmly to expose the suture line on the posterior wall. The vagina is cleansed with dry cotton sponges and the suture line is painted with tincture of merthiolate. When the wounds on both the vaginal side and the rectal side of the wall are kept clean, primary union can be expected in approximately all instances. I believe the high incidence of failure in such cases has been due to a disregard of the value of the postoperative care of the wound. The perineum should be kept free of any dressing material whatever, and secretions should be removed from the vagina more frequently than once a day, if necessary. Dry heat should be applied by means of an electric lamp during the day and removed at night.

SUMMARY AND CONCLUSIONS

Attention has been directed to the difficulty of closure of small vesicovaginal fistulas in certain situations with particular regard to the vesical sphincter and ureters.

Sulfanilamide and its derivatives have enhanced the treatment of vesicovaginal fistula in that the drug and its derivatives are able to destroy organisms within the urine in a much shorter period than had been possible formerly and are able thus to maintain the urine in a nearly sterile state during convalescence of the patient. This has been a very great asset in the improvement of end results. Meticulous care must be devoted to the patient during convalescence, to maintain the urine free from infection, to avoid incrustation in the bladder and occlusion of the catheter. The vagina should be cleaned of secretions daily.

Ureterosigmoidostomy has a definite place in the treatment of huge vesicovaginal fistulas in cases in which the bladder has been rendered incapable of again retaining urine.

Rectovaginal fistulas are best treated by complete excision of all scar tissue and re-establishment of the normal character of the rectal tube. Particular attention is directed toward those small fistulas which originate in an anal crypt, a circumstance in which it is essential that the surgeon understand the etiology of the condition and the clinical course of the patient. Postoperative care is similar to that for patients who have undergone repair of vesicovaginal fistulas in that suture lines in both the rectum and vagina must be kept clean daily. This can be done by the use of a Sims speculum, a small anoscope and dry cotton swabs. Attention to these details will greatly improve the number of instances of primary healing.

A FUNDAMENTAL ERROR IN CURRENT METHODS OF INGUINAL HERNIORRHAPHY

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COMMONLY, in the experience of the dissector and of the surgeon, structural features are encountered in surgically important areas of the body which are inadequately described in the textbooks upon which they have been dependent. In recent studies (McVay and Anson, 1940) the authors have found, for example, that the available accounts of the aponeurotic and fascial continuities from the lower abdomen into the thigh are highly conventionalized and scarcely satisfactory for the guidance of the critical surgeon. Certain of the features encountered in the study explain the frequency of recurrence, while others suggest the desirability for modification of the usual methods employed in inguinal herniorrhaphy.

The current brief report will review the salient features of inguinofemoral anatomy and describe an operation based upon this morphological study.[1] Although brief, it is hoped that this preliminary report will, by stimulating others, accelerate the accumulation of statistical data on similar cases, and will be of aid to those who have requested detailed information on the technique involved.

ANATOMY

External oblique. In the inguinal part of the abdominal wall, the external oblique is an aponeurotic plate covered on each surface by an investing fascial layer. It is, however, not a complete aponeurotic plate, since it is defective at the triangular hiatus (loosely termed the subcutaneous inguinal "ring") and in an area, lenticular in outline, caudal to the inguinal ligament (Fig. 1).[2] In these areas, which are largely devoid of aponeurotic fibers, anatomical closure is effected by the fasciae, which fuse back-to-back as they stretch across each opening. Between the crura of the "ring" they are carried downward into the scrotum as the external spermatic fascia; below the inguinal ligament they are continued inferiorly as a superficial component of the fascia lata.

Therefore, so far as the outermost of the three abdominal layers is concerned, it may be said that the barricade to herniation is incomplete; in the presence of a patent processus vaginalis the descending intestine or omentum need only enlarge the hiatus between aponeurotic crura, and dilate the surrounding fascial envelope. Since the fasciae serve to bind together adjacent aponeurotic bands so that totally they form a plate, undue stretching, in herniorrhaphy, may so weaken the covering fibrous layers that the way is paved for a recurrence; when adjacent aponeurotic bands are drawn apart, shortened by suturing, a new hernia may occur through a cleft artificially produced either in the aponeurosis itself, or distal thereto in the area of weakness between inguinal and femoral regions.

Internal oblique. Whereas the external oblique is chiefly aponeurotic in the inguinal region, the corresponding part of the internal oblique usually contains some muscle fibers, especially in its lateral portion (Fig. 2). In the inferomedial portion of the greater number of specimens, however, aponeurotic fibers diminish in size and number, and muscle fascicles become sparse. The two investing fascial layers then remain as the sole representatives of the internal oblique. On the spermatic cord, too, fascicles are few, so that this intermediate one of the funicular coats is very similar to that derived from the conjoined muscle fasciae of the external oblique.

The lower portion of the internal oblique—that is, its cremasteric portion—arises from the iliopsoas fascia as the latter leaves the pelvis for the lower extremity; its attachment to the inguinal ligament is by means of a rather delicate tissue. It is unlike the other funicular coats in that the proximal (abdominal) orifice of the tube which it

From the Department of Surgery, University Hospital, Ann Arbor, Michigan, and the Department of Anatomy, Northwestern University Medical School, Chicago, Illinois (contribution no. 345 from the latter). The anatomical aspect of the present report represents a brief consideration of earlier observations by the same authors (1938 a, 1938 b, 1940).

[1]The anatomical investigation was pursued at Northwestern University Medical School by the authors, in collaboration; the technical procedure was devised by Dr. C. B. McVay during the progress of the laboratory study and put into service at the University of Michigan with the assistance and co-operation of Dr. F. A. Coller, professor of surgery in the latter institution (B.J.A.).

[2]Figures 1 to 4 are reproduced with the permission of the Wistar Institute Press (Anat. Rec., vol. 76, pp. 225 and 227).

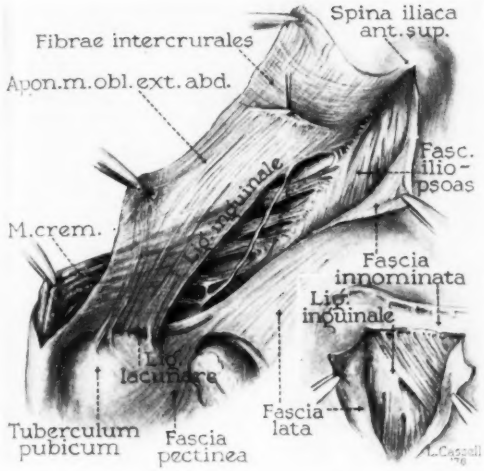

Fig. 1. The external oblique aponeurosis freed of its external layer of fascia, showing that the inguinal ligament itself is a marginal structure, separate from the fascia lata of the thigh and independent of cremasteric part of internal oblique. Inset shows fascial continuities, opposite side.

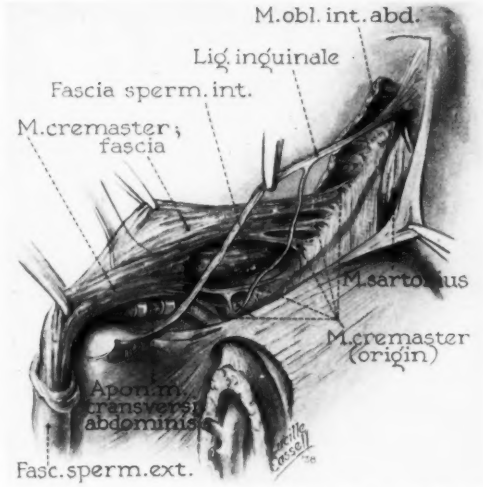

Fig. 2. The internal oblique is exposed by removal of all of the external oblique except its lowermost aponeurotic fibers (inguinal ligament); the former layer, in its cremasteric (funicular) part is partially fascial; it arises from the iliopsoas fascia, not from the inguinal ligament.

forms is an elongate oval in outline, not a circle (opened in Fig. 3); it does not completely surround the cord until that structure emerges through the subcutaneous inguinal ring. It is, therefore, a poor barricade, being capacious at its beginning and chiefly fascial through the greater part of its length.

Transversus abdominis. The inguinal portion of the transversus abdominis muscle is more aponeurotic than it is muscular (Figs. 3 and 4); its lowermost part arises from the iliopsoas fascial tube as does the cremasteric portion of the internal oblique. The insertion of this lowermost portion of the transversus is not to the inguinal ligament as one might conclude from present methods of herniorrhaphy but to Cooper's ligament on the superior pubic ramus.

Almost without exception that part which is carried downward upon the cord is purely fascial (as its name, internal spermatic fascia, would indicate). Similar to the funicular sheath is the femoral sheath; for this, the fascial layers of the transversus fuse to form the anterior component of a tubular prolongation (Fig. 4 and inset); the iliopsoas fascia forms the posterior component. The inner fascial contribution from the transversus layer is the transversalis fascia but the outer bears no special name. The femoral differs from the funicular sheath in transmitting vessels chiefly; in hernial cases it resembles the aforementioned sheath in containing (in its medial compartment) a peritoneal diverticulum.

SURGERY

All the recognized methods of inguinal herniorrhaphy which have been devised since the publication of the works of Bassini and Halsted, are alike in one respect: in each of them the various inguinal layers are sutured to the inguinal ligament. Although minor variations are legion, they seem to possess this feature in common.

The current article is entirely in agreement with those stating that simple excision of the hernial sac is adequate in a small indirect inguinal hernia when the abdominal inguinal ring is not markedly dilated; in this type of hernia, if no weakness of the posterior wall is demonstrable, passing sutures through the so called conjoined tendon and fastening it to the inguinal ligament will serve only to weaken layers and to reduce the defenses against a direct inguinal hernia. A large indirect hernia and a direct inguinal hernia present the same problems for repair. In the former, the medial extension of the dilated abdominal inguinal ring may lie next to the rectus muscle, with the result that the entire posterior wall of the inguinal canal (including the area of Hesselbach's triangle) is attenuated and the bulk of its tissue displaced medialward.

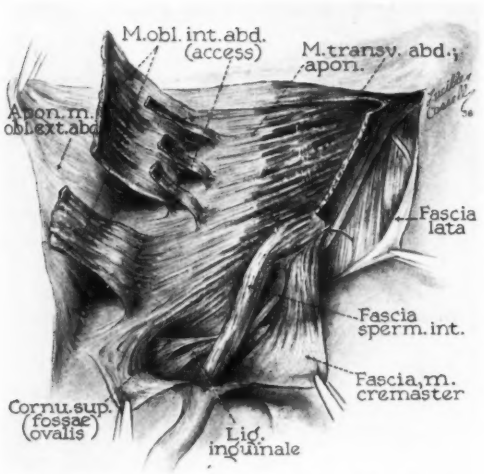

Fig. 3. The parietal part of the internal oblique has been cut and partially removed, the funicular part turned downward away from the spermatic cord. By this means it is demonstrated that the lower part of the transversus abdominis is aponeuroticofascial, not muscular, and that the muscle does not form an arching roof for the inguinal canal.

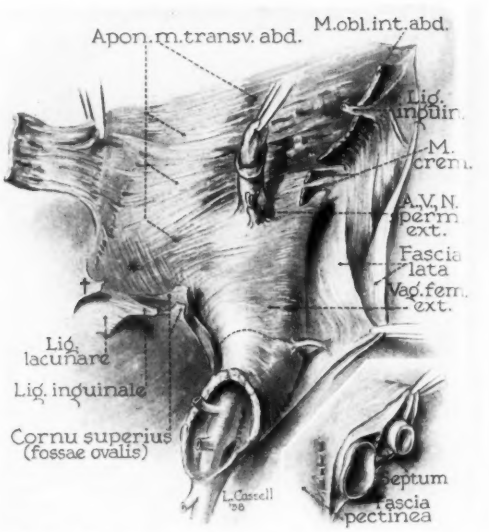

Fig. 4. The distal continuation of the transversus layer, forming the femoral sheath, has been exposed by the removal of the inguinal ligament and cremasteric muscle and fascia, and the turning aside of the fascia lata. It is demonstrated that the femoral sheath is entirely fascial, as is also the internal covering of the spermatic cord. At the asterisk the layer is thickened by an aponeurotic expansion of the rectus tendon (falx inguinalis); in the area just below this marker the transversus is inserted into the superior pubic (Cooper's ligament). Inset shows the femoral sheath, transected.

Although it is true that in the large indirect variety the inferior epigastric vessels still lie medial to the sac, the posterior wall itself must be reconstructed in a basically similar manner.

Zimmerman, in a recent article, has given an excellent presentation of the many problems encountered in the treatment of inguinal hernias. The surgical modification which he suggests—that of using a flap of external oblique aponeurosis to buttress the transversus abdominis aponeurosis in the region of Hesselbach's triangle—also employs the inguinal ligament to anchor the inguinal layers. In closure of an abdominal incision corresponding layers are sutured together in an effort to return the musculofascial anatomy to normal, and certainly in an inguinal herniorrhaphy this concept should be followed. In the more common types of inguinal herniorrhaphy the transversalis fascia and, variously, the transversus abdominis and internal oblique layers are sutured to the inguinal ligament, providing a poor substitute for their normal insertion. The inguinal ligament is not the insertion of the transversalis fascia, the transversus abdominis aponeurosis, or the internal oblique aponeurosis; its relationship to these structures is simply one of contiguity. From an anatomical standpoint this is reason enough for endeavoring to find some other structure for anchorage. Moreover, from a surgical point of view, the inguinal ligament does not make a suitable substitute for their regular insertion because of its character. The inguinal ligament, contrary to the usual conception, is loosely held in its convex position by the surrounding fasciae; it is easily shelled out of its fascial bed by the finger or a blunt instrument, to become merely the free margin of an aponeurosis which extends between the anterior superior iliac spine and the pubic tubercle (Fig. 2). Its attachment is broadened laterally by fibers of insertion passing into the iliopsoas fascia and medially by the expansion known as the lacunar ligament; between these two points it is relatively pliant (Figs. 1 and 2).

When traction is applied in a cephalad direction, simulating the pull of the muscles which might be sutured to it, it is displaced superiorly far enough to leave the lower inguinal region completely exposed beneath it (Fig. 2). In recurrent hernia occasionally the mass seems femoral in position, hernia having elevated the inguinal ligament.

If the insertion of the lower inguinal portions of the transversalis fascia and the transversus ab-

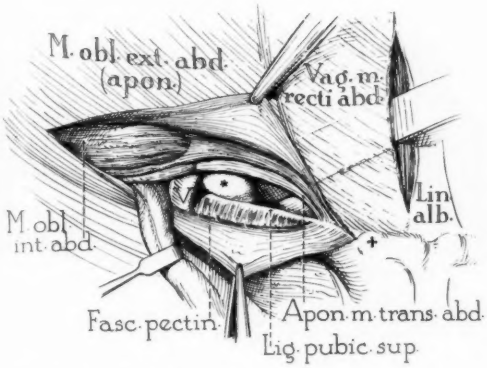

Fig. 5. Dissection demonstrating the stage in a direct inguinal herniorrhaphy in which the hernial sac has been excised. The relationship of the inguinal ligament, Cooper's ligament, and the margins of the transversus and internal oblique aponeurosis is demonstrated. The margins of the latter are sharp because the attenuated portions have been excised.

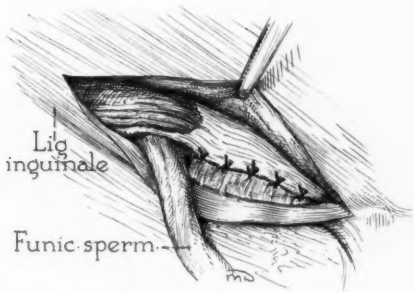

Fig. 6. Herniorrhaphy, showing the aponeurotic lower margins of the transversus and internal oblique sutured to Cooper's ligament.

dominis aponeurosis were not readily available, then there might be some reason for using the inguinal ligament; but, actually, the layers themselves and the heavy band into which they insert medially are conveniently situated for surgical use; the latter band, termed the superior pubic, or Cooper's ligament is a dense fibrous structure lying on the anterosuperior aspect of the superior pubic ramus from the pubic tubercle medially to the vicinity of the femoral vein laterally (Fig. 5). It is composed of fibers from the transversus aponeurosis and attached transversalis fascia, a lateral expansion of the rectus tendon of insertion and the pectineus fascia. Cooper's ligament is used rather consistently in the repair of femoral hernias; usually, however, the inguinal ligament as well as the transversus aponeurosis and internal oblique aponeurosis are sutured to it, as described by Moschcowitz. Dickson, however, advocated merely suturing the transversalis fascia to Cooper's ligament in the repair of a femoral hernia, ignoring the inguinal ligament. The first inguinal herniorrhaphy method known to these authors that utilized Cooper's ligament, is that described by Babcock. This method, however, uses only the medial portion of Cooper's ligament in the immediate vicinity of the pubic tubercle. Robins has subsequently advocated suturing to Cooper's ligament after the method of Babcock, and J. R. Veal and D. D. Baker utilize the superior pubic ramus in their periosteal graft.

The operation suggested is in essence a restoration of the normal inguinal anatomy. The incision of the skin and method of ligating the hernial sac are in no way different from those in general use; the principle of high ligation and of utilizing fascial or aponeurotic structures is adhered to; the suggested method differs from others in that it ignores the inguinal ligament. After the sac is removed or imbricated, as the case may be, the superior pubic (Cooper's) ligament is isolated, and freed of adjacent preperitoneal connective tissue (Fig. 5). If anomalous obturator vessels are to be ligated and severed, the small artery to the pyramidalis muscle, sometimes encountered, should also be ligated. The inferior margin of the transversus abdominis aponeurosis and attached transversalis fascia is clarified by excising any attenuated portion secondary to the hernia and freeing it from the underlying preperitoneal connective tissue (Fig. 5). This aponeurosis is then sutured to Cooper's ligament from pubic tubercle to the femoral vein by a series of interrupted silk sutures (Fig. 6). If the lower border of the internal oblique is aponeurotic, its substance is to be included in the sutures. If closure cannot be accomplished without undue tension, relaxation is accomplished after the method of Fallis. This type of closure leaves a small defect between the abdominal inguinal ring and femoral vein (Fig. 6); normal anatomy is here restored by suturing the transversalis fascia to the anterior surface of the femoral sheath. It is worthy of special comment that, if the transversus abdominis aponeurosis is sutured to Cooper's ligament as far laterally as the femoral vein, the femoral ring is obliterated; by this means the possibility of a femoral hernia is obviated.[1]

It will be noted that after the suturing of the transversus aponeurosis to the ligament of Cooper

[1]The important relationships of the lacunar ligament, Cooper's ligament, femoral ring, transversus abdominis aponeurosis and falx inguinalis have been discussed in the earlier article by the present authors (McVay and Anson, 1940). Suffice it to say that the standard descriptions of these structures and their mutual relationships are not accurate.

and the establishment of the continuity of the transversalis fascia to the anterior femoral sheath, that a pyramidal space is produced. The cord is dropped into this, and the external oblique aponeurosis is closed over it so that the spermatic cord emerges at the site of the subcutaneous inguinal ring. The obliquity of the inguinal canal is simultaneously restored. It should be acknowledged that the suturing of the layers to Cooper's ligament is technically more difficult because of the latter's deep position. There is also danger of injuring the femoral vein. A simple precaution forestalls such an accident: by the use of a vein retractor or the index finger for protection of the femoral vein, and a small ribbon retractor to keep the preperitoneal connective tissue out of the field, adequate exposure is obtained.

SUMMARY

In the repair of large indirect and direct inguinal hernias, it is recommended that the inguinal layers be sutured to Cooper's ligament and not to the inguinal ligament. It is pointed out that the inguinal ligament is neither the normal insertion of the inguinal strata nor a suitable substitute for such attachment; on the contrary, the superior pubic ligament, Cooper's ligament, which is the normal insertion, is readily accessible, intrinsically strong, and directly fixed to bone.

For those who would make critical use of anatomical illustrations the following additional descriptions may be of service. In Figure 1 the deep (innominate) fascia on the outer surface of the external oblique aponeurosis, with its contained intercrural fibers, has been removed except in a quadrangular area near the anterior superior iliac spine; this fascial layer and the proximal part of the fascia lata have been reflected inferiorly to demonstrate their continuity at the groin, and to expose the unattached central portion of the inguinal ligament. Beneath the latter the cremaster fascicles are exposed as they arise from the iliopsoas fascia and the latter's medial continuation, the deep layer of the fascia lata. The inguinal ligament is attached to the iliopsoas fascia. In the inset in Figure 1, the deep fascia over the inguinal ligament, near the iliac spine, has been drawn aside to demonstrate the continuity of the fascia lata with the innominate fascia (opposite half of body); the aponeurosis of the external oblique is continuous with the iliopsoas "fascia" (structurally, an aponeurosis. In Figure 2 only the inguinal ligament remains to represent the external oblique aponeurosis. The external spermatic fascia has been rolled downward on the spermatic cord, thus exposing the cremaster layer. The inguinal ligament, continued as the lacunar ligament, has no attachment to the pubic tubercle. The internal oblique muscle has been incised near the origin of its muscle fibers from the iliopsoas fascia and the latter's medial continuation; the cremaster layer is stretched to show its musculofascial character. The internal spermatic fascia is visible in the artificial cleft between groups of cremaster fibers (where the latter are freed of their investing fasciae). A retractor, passed deep to the cord and the cremaster, elevates the transversus abdominis aponeurosis to expose its attachment to the pubic pecten; the continuity between the transversus stratum and the femoral sheath is demonstrated. In Figure 3 the cremaster layer, including the superior crus, has been divided along the cord to demonstrate that the medial portion is entirely fascial. The transversus extends inferiorly deep to the inguinal ligament, to an insertion on the pecten; upon the spermatic cord it is chiefly fascia. In Figure 4 the proximal stump of the spermatic cord has been elevated to show the external appearance of the abdominal inguinal ring; the internal spermatic fascia has been rolled backward, leaving the constituents of the cord in their preperitoneal connective tissue (grasped by the forceps). The cremaster muscle remains as two sets of fascicles arising from the iliopsoas fascia. The inguinal ligament remains as medial and lateral stumps. The superior cornu of the fossa ovalis has been cut, only the stumps of its attachment remaining; the fascia lata has been turned lateralward to show the transition from musculo-aponeurotic transversus abdominis into fascial femoral sheath. The expansion of the rectus tendon passes to the pecten of the pubis (at *). In inset in Figure 4, the femoral sheath, transected, is shown to consist of an outer fascial layer and of an inner prolongation of the preperitoneal connective tissue.

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BASILAR INVAGINATION OF THE SKULL—SO CALLED PLATYBASIA

Report of Three Cases in Which Operation Was Done

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FREQUENTLY the stimulus of a presentation of observations at one of our meetings results in subsequent reports of similar clinical observations. Three years ago when Chamberlain reported his cases of so called platybasia most of us realized that we had probably overlooked the surgical possibilities in this condition. Now that we are aware that "platybasia," or more nearly accurately, basilar invagination of the skull, is a deformity of the occipital bone, which narrows the foramen magnum, and of the upper cervical vertebrae, which flattens the spinal canal, and that removal of the bone which is compressing the underlying brain and spinal cord usually will be followed by relief of symptoms, the syndrome is receiving more recognition.

The term "platybasia" in recent years unfortunately has been applied to a condition which is more properly described as "basilar invagination of the skull," or "basilar impression." According to anthropologists, true platybasia denotes an abnormal obtuseness of the sphenoid angle which results in a flattening of the basal, or as it is often termed, the sphenoid angle. The normal sphenoid angle is that angle which is situated between the line from the foremost point of the foramen magnum to the center of the sella turcica and from this point to the root of the nose. The angle varies normally from 115 to 150 degrees. The condition of basilar invagination of the skull has been known to anthropologists and pathologists for many years, and basically, the condition represents a developmental anomaly of the occipital bone and upper part of the cervical region of the spinal column.

According to Schueller, who described the roentgenographic features of the condition in 1905, basilar invagination is designated as an unusual change in the base of the skull, the most striking feature of which is the upward bulging of the posterior cranial fossa around the foramen magnum. When viewed from inside the cranial cavity, the base of the skull in cases in which the condition is typical exhibits an elevation of the edge of the foramen magnum lying between the pyramids of the temporal bones. The clivus in the presence of basilar invagination forms a convex bend, the vertex of which comes to lie at the level of the floor of the sella turcica so that the so called basal or sphenoid angle approaches a straight angle and not an obtuse angle, as in true platybasia, which is not associated with neurologic symptoms. The elevated portions of the occiput are considerably thinned, and the condyloid processes are more or less rudimentary. According to Schueller, in the classic case also are exhibited congenital variations of the upper cervical vertebrae. The first cervical vertebra is rudimentary in type and the posterior arch is usually fused to the lower surface of the occipital bone bounding the foramen magnum. The spinous process of the second cervical vertebra is fused with that of the third cervical vertebra.

In 1934 Ebenius described 4 cases of basilar impression (platybasia or basilar invagination) in which neurological changes were associated. Suboccipital decompression was carried out in 3 cases in an effort to relieve the symptoms. In 1938 Chamberlain described 4 cases of basilar impression (platybasia), in 2 of which suboccipital decompression had been carried out for the relief of symptoms. As a result of Chamberlain's report, interest in the condition was stimulated in this country. Although the abnormality is more properly designated as "basilar invagination," the term "platybasia" has become popular through Chamberlain's reference to it. Chamberlain has called attention to the fact that in lateral roentgenograms of the normal skull the shadows of the atlas and odontoid process will lie caudad to a line connecting the posterior edge of the hard palate and the posterior margin of the foramen magnum (Chamberlain's line).

Secondary basilar invagination may develop in the presence of any systemic skeletal disease in which the calvarium is softened; Paget's disease,

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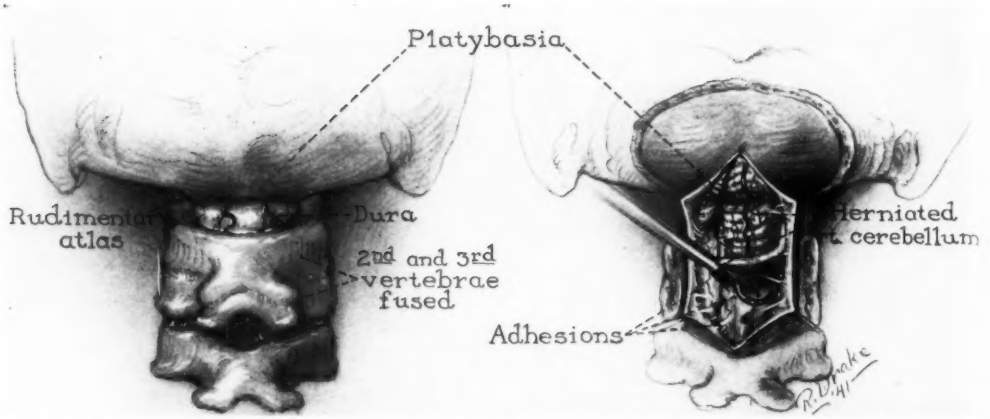

Fig. 1. Basilar invagination, showing the conditions found at operation before and after the bone was removed and the dura opened.

hyperparathyroidism, osteomalacia, and the like.

Gustafson and Oldberg reported several cases, with operative or necropsy confirmation, in which a syringomyelic picture of dissociated sensory loss was found on sensory examination of the patients. In our cases careful sensory examination failed to disclose any sensory changes except disturbance in the sense of pain occurring twice in the right side of the face. It is important to recall that the clinical picture may apparently vary somewhat from patient to patient. The stage of development at which the patient is seen may also prove confusing. We have recently seen at the clinic several patients who presented the classic roentgenologic picture of basilar invagination of the skull but who had, so far as could be found, no symptoms or signs indicative of disease of the nervous system. Whether or not these will occur at some later date remains to be seen.

It is an accepted fact that several skeletal anomalies may afflict a single patient who has basilar invagination of the skull, a fact which suggests that this condition usually rests on a congenital or developmental basis. List has comprehensively described anomalies of the occipital bone, atlas, and axis. Among the more prominent of these may be mentioned the Klippel-Feil deformity, or fusion of two or more cervical vertebrae; the Arnold-Chiari deformity, or lengthening of the pons and medulla oblongata with herniation of the cerebellum into the spinal canal; spina bifida occulta, or failure of fusion of the laminas of one or more vertebrae; and syringomyelia, or the existence of cavitation within the substance of the spinal cord, the cavity often being surrounded by a zone of gliosis. Gustafson and Oldberg emphasized the almost invariable occurrence of adhesions about the brain stem and cerebellum in the portion that has herniated through the foramen magnum. They stated that operation which consists in enlargement of the foramen magnum without opening of the dura and freeing of these adhesions is not productive of relief, and judging from our observations at operation, we concur in this opinion. It is possible that the late onset of symptoms among patients who have basilar invagination of the skull, although the skeletal deformities probably are present during most, if not all, of the patient's life, may be explained by the fact that symptoms might not occur until these adhesions form. The treatment of basilar invagination which produces symptoms is purely operative and in the reported cases has been productive of good results if the operation was not deferred too long.

REPORT OF CASES

CASE 1. The patient was a man aged 46 years, by occupation a clerk. Except for renal colic from which he had suffered 10 years prior to his coming to the clinic and the occasional finding of albuminuria of an undetermined cause, the patient's history was not remarkable. About 22 months previous to the time of examination, malaise, occasional mild diplopia, and slight unsteadiness of gait had developed. These symptoms had been completely relieved by ocular refraction and prescription of new lenses for his glasses. Eight months previous to the examination, however, definite and persistent unsteadiness of gait, which was worse in the dark, appeared and persisted. During the previous 5 months he had noted an occasional tingling type of paresthesia of the right hand and arm, while a hard cough sometimes caused his legs, and occasionally his arms, to feel momentarily very weak. Frontal and occipital head

ache, which was worse on his arising in the morning, had become more frequent. For 2 months prior to his visit to the clinic slight difficulty in the swallowing of liquids had been noted.

The patient registered at the Mayo Clinic on November 9, 1940. Results of general medical and laboratory examinations were negative, as were results of careful examination of the ocular fundi. Neurological examinations disclosed coarse nystagmus on lateral gaze in either direction. The left side of the face, including the forehead, was slightly but definitely weak. Hypesthesia to pain was present on the right side of the nose and adjacent portions of the right part of the forehead, right cheek, and upper lip. The right corneal reflex was slightly diminished. The left side of the tongue was moderately weak and definitely atrophied. The gait was markedly ataxic, but inco-ordination of the arms or legs, and adiadokocinesis or the rebound phenomenon were not present. Thus, to recapitulate, there was evidence of involvement of the midline cerebellar structures (flocculonodular lobe) and of the right fifth cranial nerve nucleus (nucleus of the descending tract of the trigeminal nerve) and of the left seventh and twelfth cranial nerves. The differential diagnosis included tumor of the brain stem, or in the midline of the cerebellum, and a vascular or degenerative lesion of the brain stem and basilar invagination of the skull. The characteristic roentgenological observations consisted of true invagination of the base of the skull in the region of the posterior cranial fossa, plus anteroposterior narrowing of the foramen magnum with congenital variation of the first three cervical vertebrae. The posterior portion of the first cervical vertebra was fused to the inferior portion of the skull, and the second and third cervical vertebrae were fused both in the body and in the posterior portions.

The pressure on the pons and medulla oblongata, caused by a narrowed anteroposterior diameter of the foramen magnum and upper cervical vertebral canal, being responsible for the symptoms, the surgical procedure indicated was that of removal of the posterior arch of the foramen magnum and spinous processes and laminae of the upper cervical vertebra.

With the patient in the upright position and under the influence of intratracheal anesthesia, a midline incision was made over the suboccipital and upper cervical regions. This incision was carried down through the skin and muscles to the suboccipital bone and the spinous processes of the cervical vertebra. The muscle and periosteum were separated from the bone of the skull, and subperiosteal dissection was carried out about the spinous processes and laminae of the upper cervical vertebra. As the dissection proceeded we could see that the arch of the atlas was absent and that the second and third cervical vertebrae were fused, as was apparent in the roentgenogram. Laminectomy was done, and the fused spinous processes and laminae of the second and third cervical vertebrae were removed. We then were able to remove the posterior arch of the foramen magnum with double rongeurs, and a modified type of suboccipital craniotomy was done. After this the dura was opened and the inferior tonsil of the right cerebellar lobe was seen to have herniated through the foramen magnum to the level of the third cervical vertebra. Definite compression was present, indicative of a narrowed foramen magnum, and adhesions existed between the meninges, the pons and cerebellum. These adhesions were divided and the cerebellar lobe was gently dissected free from the underlying structures. Some definitely anomalous vessels situated around the cerebellar tonsil prevented amputation of the tonsil, which procedure has been suggested in cases in which the condition is extreme, as it was in this one. The entire region appeared to have been compressed, but after the adhesions had been divided and the inferior cerebellar tonsil had been dissected free, much more room was provided, and definite decompression was accomplished (Fig. 1). The dura was then closed with interrupted silk sutures and the incision was closed with interrupted catgut in the muscle and silk in the skin.

In the preceding case the condition was so typical from the diagnostic and surgical standpoints that it really seemed that there was no question that surgical intervention was a safe and logical procedure. However, in the next case, compression was so great that respiratory difficulties were encountered throughout operation, and it was necessary to leave the dura open in order to obtain the maximal amount of relief.

CASE 2. A boy 16 years old was brought to the clinic on March 3, 1941, complaining of difficulty in swallowing liquids, a difficulty that had been present for 1½ to 1¾ years prior to the time of his visit. Solid food could be taken without any difficulty. During the 2 years prior to the time of his visit he had suffered from some degree of weakness and loss of weight. He had always had some limitation of lateral motion of the neck, without pain.

Aside from osteomyelitis of the right femur, which had developed in 1934 and had taken a year to heal, the patient had remained in good health until about 1938, when he had begun to experience frequent attacks of stiffness and soreness in his neck. A violent cough or sneeze invariably would produce pain in nape of neck, more on the left than right, with extension of the pain up over occiput. Lying down would relieve this distress within a few minutes.

Nothing more of significance was noted until about March, 1939, when he had begun to experience difficulty in swallowing liquids. He would choke on liquids and had trouble with phlegm in his throat in the mornings. During latter half of 1939, he had begun to notice difficulty in walking and marked clumsiness developed in use of his hands. These symptoms had been progressive.

Shortly before the patient was admitted the father had noticed that while the boy was sleeping, he breathed in an unusual manner. Respirations which were shallow and frequent were followed by about three deep breaths taken slowly, followed in turn by a period of apnea which lasted for as long as 30 seconds. Then the process was repeated.

During the last 2 years prior to his visit, the patient had increased in height at least 12 inches (30 cm.).

The essential observations included a cerebellar type of ataxia, which was more marked on the left side, and elicitation of Romberg's sign. The patellar and achilles reflexes were increased and Babinski's, Chaddock's and Rossolimo's signs were elicited bilaterally. Rapid horizontal nystagmus was marked on the patient's looking toward either side, with slight nystagmus on his looking upward. Vibratory sense was moderately decreased at both external malleoli. The muscles of both upper extremities were definitely weak, but the strength in the lower extremities seemed normal.

Roentgenological examination of the cervical part of the spinal column and the skull revealed a congenital anomaly of the upper part of the cervical region of the spinal column, with a well defined basilar invagination deformity. There was an anomalous deviation of the body of the second cervical vertebra with resultant deformity of the odontoid process and anterior portion of the first cervical vertebra; there was also spina bifida occulta of the sixth and seventh cervical vertebrae. The lateral view of the skull and upper

part of the cervical region of the spinal column revealed deformity of the foramen magnum and first cervical vertebra, typical of basilar invagination.

The patient was operated on on March 8, 1941, at which time suboccipital decompression and laminectomy in the upper part of the cervical region was done. Because of the respiratory symptoms when the patient was asleep it was thought best to attempt to carry out the operation with the patient under the influence of intratracheal anesthesia. Induction of anesthesia was begun by the intravenous administration of pentothal sodium, when the patient's respiration ceased. Under artificial respiration he began to breathe normally and regional anesthesia was used thereafter throughout. With the patient in the upright position through a midline incision, the arches of the first, second, and third cervical vertebrae were removed. The second and third were fused and there was definite projection of the left side of the laminae which were compressing the medulla oblongata. Suboccipital craniotomy consisted of removal of the arch of the foramen magnum and the adjacent bone, for about 4 centimeters. At about this time the patient's breathing became very labored and he became comatose. We quickly opened the dura and found marked herniation of both cerebellar lobes to the level of the third cervical vertebra. Adhesions between the meninges, medulla oblongata, and the brain also were present; these were rapidly divided. When we attempted to close the dura compression of the underlying part of the brain occurred. For that reason the dura was left open. Cargile membrane was used for closure of the opening, and the muscles were closed in the usual manner.

After this operation the patient recovered completely and was allowed to return to his home. There was marked absence of nocturnal dyspnea, and the patient's general condition was greatly improved. In a letter 2 months after the operation it was stated that he was greatly relieved of all symptoms, was swallowing normally, and was walking and sleeping without change in respiratory rate.

In the third case, the patient, although incapacitated for work, did not have a classical syndrome, although the roentgenograms of the head were typical. At operation the typical flat foramen magnum was found, with basilar invagination of the skull, but there were no anomalies of the cervical vertebrae and little herniation of the cerebellar lobes. The postoperative improvement, although it was subjective, indicated that operation was justified.

CASE 3. A man, aged 52 years, was admitted to the clinic on April 2, 1941, complaining of numbness and weakness of the legs which had occurred intermittently during the previous 6 months. In October, 1940, the patient had noticed some dizziness as he arose from the supine position. This had been associated with increased bilateral "tiredness" of his legs. A sensation described as "electric pins and needles" had seemed to affect the front of his feet and legs to his knees on his climbing the stairs. By November, 1940, this condition had progressed to such a point that it was necessary for him to quit his work. His legs had continued to become weaker, particularly about the knees. In February, 1941, he had noted the same sensation in his arms as had been present in his legs, associated with a sensation of numbness in the upper part of the thoracic region of the spinal column. This had been intermittent. During the 3 months prior to his coming to the clinic he had noted paresthesia involving both lower extremities, but more on the right side. For 4 or 5 months he had experienced intermittent attacks of numbness that had involved the right side of his head.

On examination bilateral increase of patellar reflexes and a static tremor on the left were found. Definite nystagmus was detected on lateral gaze. Roentgenological examination of the skull revealed flattening of the foramen magnum and typical basilar invagination of the skull. The spinal fluid was under normal pressure. Subarachnoid block was not present, and the content of protein was normal. There were, however, a slow increase and a rapid decrease in the pressure of the spinal fluid on and after performance of the Queckenstedt or jugular compression test.

On April 12, 1941, with the patient in the upright position and under intratracheal anesthesia, a midline incision was made over the occipital and upper cervical regions. Fusion of the upper cervical vertebrae was not present, and when the arch of the foramen magnum was removed the dura was opened. Although herniation of the cerebellar lobes was not so marked as in previous cases, definite adhesions were situated between the meninges and the inferior poles of the cerebellar lobe. After an uneventful convalescence the patient returned to his home.

SUMMARY

Three patients with roentgenographic picture of basilar invagination of the skull are reported. In 2 of the cases associated anomalies of the upper cervical vertebrae also were present. Clinical symptoms suggested involvement of the spinal cord in the upper cervical region and the brain stem in all 3 cases, whereas neurological signs indicated a lesion of the cerebellum or its tracts in all cases, and in one case each, a lesion of the brain stem, and a lesion of the spinal cord in the upper cervical region. Marked respiratory difficulty occurred in one case.

Operation was carried out in each case, and adhesions between the meninges and inferior poles of the cerebellar lobes and brain stem were present and were freed in all cases. In 2 cases marked herniation of portions of the cerebellar lobes occurred. Relief from symptoms was striking in all cases.

The characteristic roentgenographic picture of basilar invagination of the skull has been encountered among several patients who had neither the clinical symptoms or signs of involvement of the nervous system.

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AN EXTRA-ARTICULAR OPERATION FOR RECURRENT DISLOCATION OF THE SHOULDER JOINT

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FOR the treatment of habitual dislocation of the shoulder the writer introduces a simple and improved method which is accomplished by an attack that intends to be extra-articular throughout.[1] The technique to be described was developed to replace the longer and more complicated procedures employed today, in which articular exposure, excessive manipulation and injury to synovial lining and capsule are objectionable features.

Nicola, in considering the pathology underlying recurrent dislocation of the shoulder, listed three main groups: (1) bony, (2) capsular, and (3) muscular.

"1. In the bony group are included: (a) Defects in the head of the humerus, either congenital or acquired after the first dislocation. Atrophy of the head of the humerus, infantile paralysis, or congenital defects. (b) Defects in the glenoid cavity, consisting of acquired fracture of the edge, or shallowness of a congenital type. (c) Fracture of the greater or lesser tuberosities of the humerus.

"2. In the capsular group are included: (a) Detachment of the joint capsule from the anterior or inferior margins of the glenoid fossa. (b) Enlargement of the joint capsule from relaxation following repeated tears.

"3. In the muscular group are included: (a) Weakness of the supraspinatus and infraspinatus muscles. (b) Contracted pectoralis major, teres minor, and latissimus dorsi."

According to Steindler and others, the principal pathological feature in habitual dislocation of the shoulder is the relaxation of the antero-inferior capsular apparatus. The original rent in the capsule is filled in by fibrous tissue and the resulting redundancy predisposes to subsequent dislocations, which occur on abduction and outward rotation of the arm, in many instances during epileptic seizures. On the other hand, Bankart believes that the underlying pathology in traumatic dislocation of the shoulder joint occurs when the "head of the humerus shears off the fibrous capsule of the joint from its attachment to the fibrocartilaginous glenoid ligament."

For the purpose of contrast, we need to review briefly the essential steps employed today in the surgery devised to correct habitual dislocation of the shoulder joint. Of the methods that depend upon muscular or tendinous slings for the stabilization of the joint, the Ehrlich-Clairmont myoplasty, and the Nicola tenoplasty are the most widely known. The Ehrlich-Clairmont operation utilizes a flap of muscle taken from the posterior aspect of the deltoid muscle and passed anteriorly through the quadrilateral space to be sutured to the tendon of the subscapularis muscle as it inserts on the lesser tuberosity of the humerus. Because of its extensive surgery and its frequent failures, this operation fell into disuse. The Nicola operation utilizes the long tendon of the biceps muscle to keep the head of the humerus from dislocating from the glenoid fossa. After adequate exposure of the shoulder joint, the capsule is opened, and the long tendon is divided below the level of the transverse humeral ligament. A tunnel is then drilled from this point of division upward through the head of the humerus to the center of its articular surface. The proximal end of the tendon is pulled through the osseous tunnel and reunited with its distal end by interrupted sutures. Because of the excessive disruption and trauma to the joint capsule and to the articular surface of the head of the humerus, Berkheiser found it advisable to modify Nicola's operation by drilling vertically and in a downward direction through the lesser tuberosity of the humerus. This departure from the original technique eliminates the undesirable step of having to drill through the center of the articular surface of the head of the humerus, but it does not do away with the necessity of laying the joint cavity wide open.

Capsulorrhaphy or plication of the capsule has been attempted by many, but seldom found to be curative, and therefore, is never recommended alone. Repair of the glenoid ligament alone or in combination with capsule plication and shortening of the subscapularis tendon is also seldom employed.

[1]The technique herein described was developed and perfected in the Department of Anatomy of the University of Illinois, College of Medicine, with the aid of Dr. Otto F. Kampmeier, Professor of Anatomy and Head of the Department. The writer also wishes to thank Dr. Jack Kirschbaum, Pathologist of the Cook County Hospital, for his invaluable assistance in furnishing fresh postmortem material to further the development of the technique.

Fig. 1, left. The arm is abducted to 45 degrees and the forearm is in complete supination. The dotted line represents an incision, beginning at the coracoid process and carried down about 5 centimeters from the middle level of the shaft of the humerus.

Fig. 2. Some fibers of the anterior lamina of the tendon of the pectoralis major are cut along its insertion on the lateral aspect of the intertubercular groove.

Of the many procedures that resort to reconstruction of the bony part of the glenoid fossa, those described by Bankart and Oudard are most widely used. In Bankart's operation the coracoid process is divided and drawn downward with its muscle attachments. The subscapularis muscle is severed from its insertion on the lesser tuberosity and drawn inward. After the anterior aspect of the shoulder joint is exposed, the capsule is elevated and kept in position with a small bony wedge. The fibrous capsule is then fixed to the bone along the anterior margin of the glenoid and the subscapularis tendon and the detached coracoid process are reattached.

In the operation designed by Oudard a bony buttress is formed in front of the shoulder joint. He accomplishes this by splitting obliquely the coracoid process and lowering the lateral half, on which the tendons of the coracobrachialis and the short head of the biceps are attached, to a point just in front of the glenoid lip of the shoulder joint. Originally, Oudard employed a bone graft to increase the length of the coracoid process when lowering it in front of the shoulder joint.

Of the operations employed today for recurrent dislocations of the shoulder joint, most surgeons believe that the operation devised by Nicola gives the highest percentage of good results. Although this may be true, we must admit that his approach gives less attention to anatomical and physiological considerations than is desirable. The Nicola operation requires the capsule to be laid wide open, the transverse humeral ligament to be cut, and the entire tendon of the long head of the biceps brachii muscle to be displaced from its normal and important anatomical relationship.[1]

[1]According to Gray's *Anatomy of the Human Body*, 20th ed., 1918, "the peculiar relations of the tendon of the long head of the biceps brachii to the shoulder joint appear to subserve various purposes. In the first place by its connection with the shoulder and elbow the muscle harmonizes the action of the two joints, and acts as an elastic ligament in all positions. It strengthens the upper part of the articular cavity, and prevents the head of the humerus from being pressed up against the acromium, when the deltoideus contracts; it thus fixes the head of the humerus as the center of motion in the glenoid cavity. By its passage along the intertubercular groove it assists the steadying of the head of the humerus in the various movements of the arm. When the arm is raised from the side it assists the supraspinatus and infraspinatus in rotating the head of the humerus in the glenoid cavity, and prevents its slipping over its lower edge, or being displaced by the action of the latissimus dorsi and pectoralis major, as in climbing, and many other such movements."

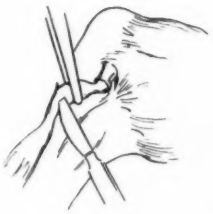
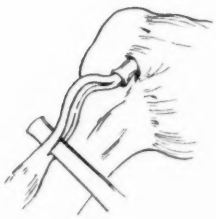


Fig. 3



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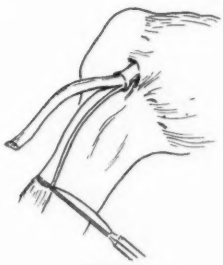

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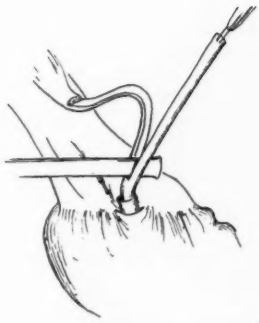

Fig. 6

Fig. 3. With arm still in abduction, the long tendon of the biceps is split lengthwise into ventral and dorsal halves, by first passing sharp point of scalpel through its central axis.

Fig. 4. Further splitting of the long tendon with the blunt end of the scalpel.

Fig. 5. The anterior or ventral half of the split tendon is cut across at its lower end, near the muscle belly.

Fig. 6. The arm is next adducted, and then it is raised forward and upward to an angle of 135 degrees or more. The intra-articular portion of the long tendon of the biceps is thus exteriorized, thereby making it possible to proceed with the visible blunt division of the tendon in a direction toward its attachment on the supraglenoid tubercle.

Another highly undesirable feature of Nicola's procedure is the marked trauma to the articular surface of the humerus when the bit of the drill breaks through that surface, causing jagged edges. Wishing to retain the basic principle of Nicola, yet at the same time being guided more strictly by anatomical considerations in the treatment or stabilization of a shoulder joint subject to recurrent dislocations, the writer set out to devise a method which would reduce to a minimum the interference and trauma to its various components. The technique to be described herein was developed on embalmed and then on fresh autopsy cadavers. Experimentally, the shoulders of fresh cadavers were first dislocated, and then opened. Inspection revealed marked stretching and tearing of the shoulder capsule, especially at its anteroinferior aspect. The author's "extra-articular" operation was carried out, and found to be satisfactory in holding the head of the humerus securely in the glenoid fossa, even when an attempt was made to redislocate it.

THE METHOD

The proposed method of operation is as follows: With the arm abducted to 45 degrees and the forearm in complete supination (Fig. 1), an incision is made from the site of the coracoid process downward to about 5 centimeters from the middle level of the shaft of the humerus, and the deltoid muscle is exposed. The fibers of the deltoid are bluntly split as far down as possible and pulled aside to expose the shoulder joint and the upper one-third of the shaft of the humerus. In order to uncover completely the long head of the biceps from where it leaves the joint capsule to as far as the muscle belly, some fibers of the anterior lamina of the tendon of the pectoralis major[1] are cut along its insertion on the lateral aspect of the intertubercular groove (Fig. 2). Now by flexing the elbow, the long tendon of the biceps relaxes, and it can be easily freed from its loose investing areolar tissue with the blunt end of a scalpel. Once the tendon is lifted from its bed, further gentle stripping frees it along its entire course, from the lower border of the joint capsule to the beginning of the muscle belly. To illustrate the range of sliding of the tendon, the arm is adducted and raised to an angle of about 135 degrees (Fig. 6). This maneuver permits the intracapsular portion of the long head of the biceps to emerge for a distance of approximately 5 centimeters or more, thereby making most of it extracapsular. Conversely, by allowing the arm to come down to the side of the trunk again, the originally intra-articular portion of the tendon is seen to glide back into the joint capsule. Proceeding with the operation, the arm is kept in abduction and the elbow is extended, and the forearm is placed in a position halfway between pronation and supination. While the extremity is held in that position,

[1] In Cunningham's *Textbook of Anatomy*, the description of the insertion of the pectoralis major muscle reads: "The tendon at its insertion forms a fascial expansion which extends upwards over the biceps tendon to the capsule of the shoulder joint. In this way a bi-laminar tendon is produced, united along its inferior border." While studying the relationship of the insertion to the pectoralis major to the long tendon of the biceps, the writer observed that this tendon, while gliding down through the tunnel provided by the split tendon, is kept closely applied to the surface of the humerus. The latter relationship, therefore, affords an efficient leverage for the long tendon when the biceps brachii contracts.

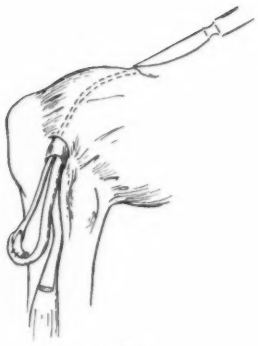

Fig. 7

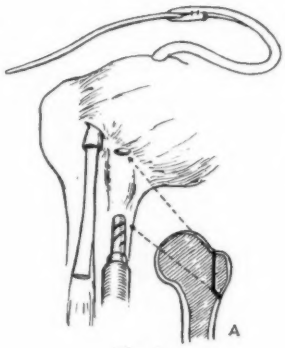

Fig. 8

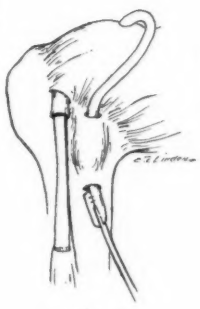

Fig. 9

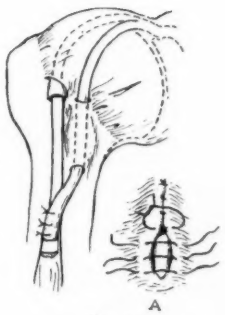

Fig. 10

Fig. 7. The lower end of the anterior half of the split tendon is fastened with two silk sutures to the eyelet of a flexible probe. The other end of the probe is passed through the synovial canal of the tendon almost as far as the supraglenoid tubercle. Here the tip of the probe is pressed upward against the roof of the capsule, and a stab wound is made with a scalpel at the point of projection.

Fig. 8. The probe is pulled gently through the opening, bringing through the other end with attached tendon half. A, Represents a sagittal section taken through the head and shaft of the humerus in a plane that is longitudinal with the canal drilled through the lesser tuberosity.

Fig. 9. The tip of the flexible probe is passed into the newly formed osseous canal until it emerges from the lower opening. The probe is then pulled forcibly through the canal, carrying with it the attached end of the exteriorized tendon.

Fig. 10. An illustration of the ultimate relationship of the displaced tendon to the glenohumeral articulation and capsule of the shoulder joint. A, Further illustrates additional plication of a lax capsule by several interrupted Lembert silk sutures. This step invaginates the exteriorized half of the long tendon within the external surface of the capsule.

the long tendon of the biceps is split lengthwise into ventral and dorsal halves (Fig. 3, 4). To accomplish this the operator should gently compress the tendon with an anatomical forceps which flattens it lateromedially permitting the scalpel to pass more easily and accurately through its central axis (Fig. 3). The initial passage of the scalpel's point through the tendon is made preferably close to the tendon's exit from the joint capsule. Further splitting of the tendon is continued with the blunt end of the scalpel as far downward as the belly of the biceps muscle and the anterior or ventral half of the split tendon is then severed transversely at its lower end, that is, near the muscle belly (Fig. 5). Additional splitting of the tendon in the upward direction is not attempted until the elbow is flexed, and the arm adducted and then brought forward and upward to more than 135 degrees. This movement exteriorizes the greater portion of the intra-articular portion of the long tendon of the biceps, thereby making it possible to continue the visible blunt division of the tendon, as much as the intact transverse humeral ligament will permit, in the direction proximal, that is, toward the attachment of the tendon on the supraglenoid tubercle (Fig. 6). Then lowering the extremity to the side of the trunk and extending the elbow joint, both halves of the split long tendon are seen to slide back into their intracapsular relationship. Next, the lower end of the anterior half of the split tendon is fastened with 2 silk sutures to the eyelet of a flexible probe, and the other end of the probe passed upward through the synovial canal of the tendon almost as far as the supraglenoid tubercle. Here, the tip of the probe is pressed upward against the roof of the capsule, and a stab wound made with the scalpel at the point of projection (Fig. 7). Then the probe is pulled gently through the opening bringing through the other end with attached tendon half (Fig. 8).

By means of a 5 to 6 millimeter bit, a tunnel is formed in the lesser tuberosity by drilling from its apex vertically downward, that is parallel with the long axis of the humeral shaft for a distance of 2.5 centimeters. The bit is then withdrawn, placed on the outer surface of the tuberosity at an obtuse angle with the lower end of that vertical tunnel, and a second tunnel is drilled until it communicates with the vertical one (Fig. 8), so establishing a common canal through the lesser tuberosity. (To break down the crest of bone that might remain at the angle where the two bony tunnels join, as shown at a in Figure 8, the drill bit is moved appropriately to and fro before it is withdrawn). The tip of the flexible probe is now passed into this newly formed osseous canal until it emerges from the lower opening, and the

probe then pulled forcibly through carrying with it the attached end of the exteriorized tendon (Fig. 9).

Before proceeding with the final step, it is important to eliminate completely any wrinkling of the tendon which may have been imparted to it in the course of its handling. Such precaution is secured, when the arm is in adduction and the elbow flexed, by grasping the lower end of the tendon with a hemostat and forcibly pulling it, and at the same time, pushing the head of the humerus toward the glenoid fossa. Having acquired a maximum degree of tautness, the tendon is finally reattached to the intact dorsal half of the biceps tendon by several interrupted silk sutures. Figure 10 illustrates this ultimate relationship of the displaced tendon to the glenohumeral articulation and capsule of the shoulder joint. This figure should indicate also that closer apposition of the head of the humerus to the glenoid fossa is achieved, as well as the re-enforcement of the weakened anterior aspect of the capsule.

The surgical procedure, just described, is one which, in comparison with that of Nicola's, is practically extra-articular (except for the possible tearing of the synovial sheath surrounding the biceps tendon) and, therefore, neither lays open the joint to sepsis nor damages it with subsequent distorting processes. The joint capsule and the transverse humeral ligament are kept intact, and the transplantation of the entire long head of the biceps muscle from its important relationship is made unnecessary. The time required to carry out the operation is considerably shorter than that for the other operations mentioned. Because of the apparent decrease in trauma one may expect less postoperative fibrosis and consequently a diminution in the number of cases with limitation of motion.

In cases in which a stretched articular capsule exists, the following additional step may be included with definite advantage. Several interrupted Lembert silk sutures are made to invaginate the exteriorized half of the long tendon within the external surface of the capsule, as shown in the insert of a, Figure 10. Such additional plication of the lax capsule not only diminishes the size of the stretched capsule, but also strengthens the displaced tendon in its course down to the upper opening of the osseous canal in the lesser tuberosity.

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HELIUM IN ENCEPHALOGRAPHY

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SINCE the introduction of encephalography by Dandy in 1919, many attempts have been made to prevent the severe headaches, nausea, and other disagreeable symptoms which follow the use of this valuable diagnostic procedure. In 1924 Liberson introduced a continuous flow apparatus for this purpose, and in 1932 Dyke and Davidoff advocated the use of minimal amounts of air in order to reduce symptoms to a minimum. Schwab, Fine, and Mixter reported in 1937 that good results can be obtained by replacing the cerebrospinal fluid with oxygen and by following this procedure with oxygen inhalation to prevent contamination of the injected gas by gases from the blood stream. In 1939 Scott suggested the subcutaneous injection of atropine to ameliorate the "usual" symptoms produced by encephalography.

The present report deals with experiments carried on since 1938 in an effort to reduce untoward symptoms after encephalography to a minimum. Excellent results have been obtained consistently by replacing the cerebrospinal fluid with helium gas and by following this procedure with inhalation of pure oxygen until all of the symptoms have subsided. A consideration of the rationale of this practice and a comparison between this method and other methods of performing encephalography show that it enjoys definite theoretical and actual advantages.

It is believed that measures which hasten escape of gas from the subarachnoid space and ventricles after encephalography tend to alleviate postencephalographic distress. Unfortunately, it is not practicable to aspirate gas from the subarachnoid space, and the only avenue of escape for this material is into the blood stream and thence to the lungs, where it leaves the body. The rate of escape of a gas by this route is dependent upon physical factors which can be utilized to advantage.

The speed with which any gas passes from the subarachnoid space through vessel walls and into the blood stream depends (a) on the difference in pressure between the gas in the subarachnoid space and the same gas in the blood stream and (b) on the inherent diffusibility of the gas itself.

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The diffusibility of any gas depends upon the size of its molecules. Light gases made up of small molecules diffuse relatively more rapidly than heavier gases. According to Graham's law, the diffusion rate of any gas is inversely proportional to the square root of its molecular weight. Helium with a molecular weight of 4, nitrogen with a molecular weight of 28, and oxygen with a molecular weight of 32 have diffusion rates inversely proportional to 2, 5.3, and 5.7, respectively. In other words, the diffusion rate of helium is almost three times that of either oxygen or nitrogen. The only gas which diffuses faster than helium is hydrogen, which has the disadvantage of being dangerously combustible.

From theoretical considerations alone, it was anticipated that helium would escape from the subarachnoid space much faster than either air or oxygen which are customarily used to replace the cerebrospinal fluid. Repeated x-ray examinations of a number of patients showed that this is true, but these findings played no part in establishing the superiority of helium over other gases. Each gas investigated was judged solely by the duration of the symptoms which it provoked when used as an agent for replacing the cerebrospinal fluid.

Finding a safe, easily procured and rapidly diffusing gas suitable for injection into the subarachnoid space is not enough to insure the comfort of the encephalographic patient. Immediately upon substituting a gas for the cerebrospinal fluid, a great deal of gaseous transposition may begin. If air is used, oxygen will flow out of this subarachnoid air and into the relatively oxygen-poor venous blood. At the same time, nitrogen and carbon dioxide will flow out of the blood stream and into the subarachnoid space. Eventually a state of equilibrium will be reached, and the gases in the subarachnoid space will exist in the same proportions and under the same pressures as the gases in the venous blood. When such a condition becomes established, removal of the subarachnoid gas mixture proceeds very slowly, and gas can be demonstrated in the subarachnoid space or ventricles for days. The average duration of symptoms after simple air encephalography is about 2½ days.

When pure oxygen is used to replace the cerebrospinal fluid, it too is immediately invaded by gases from the blood while it is itself escaping

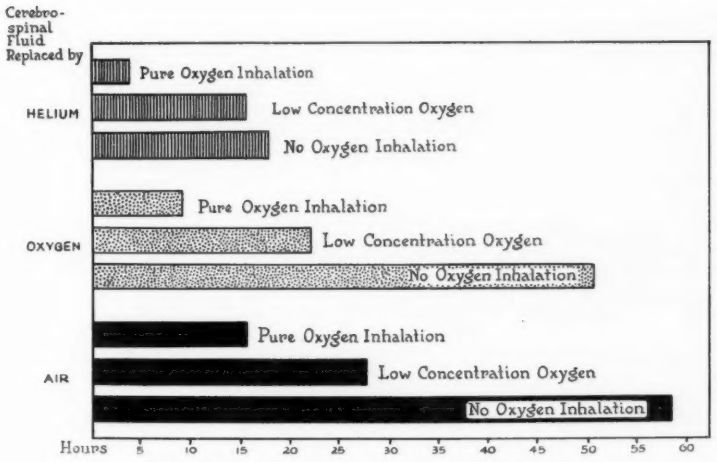

Fig. 1. Duration of symptoms after encephalography.

from the subarachnoid space. In time the subarachnoid space becomes filled with a mixture of the gases which exist in venous blood, and this mixture is indistinguishable from the residual gases in the subarachnoid space after air encephalography, although it is smaller in amount. This rapid invasion of injected gas prevents any very striking results from following the use of oxygen to replace the cerebrospinal fluid.

Schwab, Fine, and Mixter appreciated the futility of injecting oxygen under such circumstances and employed oxygen inhalation to prevent infiltration of the injected gas by gases from the blood stream. When pure oxygen is breathed, the circulating blood can be washed free of the major part of its other gases. When pure oxygen is inhaled after encephalography, part of the dissolved gas in the blood flows out of the blood stream into the oxygen in the alveoli instead of out into the oxygen in the subarachnoid space. In this way part of the infiltration of subarachnoid gas is prevented.

Two major criticisms, both in favor of the helium method, can be leveled at the use of oxygen encephalography followed by oxygen inhalation. The first is that by using oxygen to replace the cerebrospinal fluid, a slowly diffusing gas is employed, and its escape from the subarachnoid space is necessarily slow. Helium under the same circumstances diffuses almost three times as rapidly. The second criticism is that when pure oxygen is inhaled after oxygen encephalography, the blood carries an increased amount of oxygen in simple solution, and the oxygen from the subarachnoid space is required to enter the blood stream against this increased oxygen pressure. In other words, the pressure difference, or filtration pressure, between the subarachnoid oxygen and the oxygen in the blood stream is decreased when pure oxygen is inhaled, and this hampers filtration of oxygen into the blood. Helium, on the other hand, in addition to escaping quickly due to its rapid diffusion rate, filters into the blood stream without difficulty when it is used to replace the cerebrospinal fluid, because the helium pressure in the subarachnoid space is relatively very great, and the helium pressure in the blood is practically zero. This provides an excellent filtration pressure difference which oxygen can never enjoy. The additional use of oxygen inhalation after helium encephalography retards invasion of subarachnoid helium by blood gases without interfering with the escape of helium.

In order to compare various methods of encephalography, 82 patients selected at random were treated as follows: In one group the cerebrospinal fluid was replaced by air, in another group by oxygen, and in a third group by helium. Some patients in each group next received pure oxygen by Boothby, Lovelace, and Bulbulian[1] mask until all symptoms had subsided, others were given low concentrations of oxygen by nasal catheter or other device until they were symptom-free and the rest received no oxygen therapy whatsoever. In every case pentothal sodium or avertin was used to provide anesthesia during replacement of the cerebrospinal fluid, the fluid was

[1] J. Am. M. Ass., 1939, 113: 477.

removed in quantities of 20 cubic centimeters and was immediately replaced by gas and the postoperative care of the patient was carefully standardized in order to provide as constant conditions as possible throughout the study.

Of the 82 patients studied, only 41 were considered reliable enough to report. Some were rejected because they were too young to give dependable answers and others because they were suffering from psychoses which made them unreliable. Patients who gave a history of frequent or persistent headaches, vertigo or other symptoms before encephalography were eliminated, as were those whose postencephalographic symptoms disappeared during sleep and hence could not be classified accurately as to the exact time of disappearance.

The results obtained are shown in Figure 1.

From the figures in Table I, it is apparent that helium encephalography followed by oxygen inhalation produced symptoms lasting less than half as long as those produced by oxygen encephalography plus oxygen inhalation and about one-fifteenth as long as the symptoms produced by encephalography as it is usually performed with air. It is also apparent from these figures that the effectiveness of postencephalographic oxygen inhalation depends upon concentration of oxygen inhaled, since inhalation of low concentrations had much less effect than inhalation of pure gas.

TABLE I

	Average duration of symptoms—hrs.
Air encephalography followed by:	
No oxygen inhalation	58½
Low concentration oxygen	27½
Pure oxygen inhalation	15¾
Oxygen encephalography followed by:	
No oxygen inhalation	50¾
Low concentration oxygen	22
Pure oxygen inhalation	9
Helium encephalography followed by:	
No oxygen inhalation	18
Low concentration oxygen	16¾
Pure oxygen inhalation	3¾

Among the cases reported are 2 in which encephalography was performed by more than one method. One patient suffered for 24 hours after simple air encephalography and for 19 hours after air encephalography followed by inhalation of low concentrations of oxygen. Another patient who suffered for 34 hours after simple air encephalography was symptom-free 3 hours and 45 minutes after helium encephalography followed by inhalation of pure oxygen.

Since this paper was written, all cases in which patients were examined with encephalograms have been reviewed. It has been noted that in approximately 75 per cent of the cases in which the encephalograms were made under pentothal sodium anesthesia, poor filling of the ventricular system resulted, whereas, in those cases in which encephalograms were performed under local anesthesia, unsatisfactory filling resulted in less than 20 per cent. In 14 cases in which poor filling of the ventricular system resulted under pentothal sodium anesthesia, further encephalographic studies were done under local anesthesia and, in only 1 case were we unable to obtain satisfactory results. As a further check on this, we deliberately used pentothal sodium in 10 cases and then, at a later date, repeated the procedure under local anesthesia. In 4 of these cases, no filling of the ventricular system was obtained under pentothal sodium anesthesia, and in 2 others, there was unsatisfactory filling. When repeated under local anesthesia, satisfactory filling was obtained in 9 of the cases and unsatisfactory filling was seen in 1 of the 4 in which there was no air in the ventricles when pentothal sodium was used.

SUMMARY

When the cerebrospinal fluid was replaced by helium gas and the patient was then allowed to inhale pure oxygen until symptom-free, the average duration of symptoms was 3¾ hours.

When oxygen was used to replace the cerebrospinal fluid and pure oxygen was then inhaled, the symptoms lasted 9 hours, or more than twice as long.

The symptoms following simple air encephalography as it is usually performed lasted 58½ hours, or almost 2½ days. This is about 15 times as long as the results obtained with helium.

The rationale of helium encephalography is discussed, and various methods of encephalography are compared on the basis of duration of postencephalographic symptoms which they produce.

Pentothal sodium anesthesia has proved unsatisfactory for encephalography. The best results are obtained when local anesthesia only is used preceding spinal puncture. The only advantage of pentothal sodium or general anesthesia is that the patient is not aware of the headache during the immediate procedure.

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CANCER OF THE BREAST

Ten Year End-Results

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THE following is a report of the 10 year end-results of radical operation for cancer of the breast operated upon at the Massachusetts General Hospital during the 5 year period, 1927–1931 inclusive. The cases are the same as those previously reported on a 5 year basis in 1936 and 1939. Several papers on the results of radical operation for cancer of the breast have been published by the author or his associates in the Tumor Clinic on a 5 year basis. A detailed analysis of these cases will not be repeated here (2, 3, 4, 7, 8, 9). In previous reports the patients in the private wards were included with those operated upon in the general hospital. The results have constantly improved since the first study was made in 1907, and the percentage of 5 year cures in the last group studied (1930–1932) was 45 per cent. It was noted that in an appreciable number of cases the recurrence did not appear until after the fifth year, and this review is made to determine, if possible, the number of, and reason for, this late recurrence.

The cases of patients operated upon in the General Hospital only have been studied, for it was deemed too difficult to follow the private patients operated upon by many different surgeons, several of whom are now dead. The results of treatment of cancer have always been found to be better in the patients operated on in private wards, even when the two series are placed in comparable groups as regards duration, extent of disease, histiological index of malignancy, age, etc. The reason for this is obscure, but the fact that the prognosis is better in patients who may be said to be in the higher social group has been pointed out by several observers (1, 5, 6, 10, 11, 12). The percentage of 5 year cures is therefore slightly less than that reported in the other communications.

The group studied consisted of 147 cases and with few exceptions these patients were operated upon by members of the tumor clinic staff. The 10 year end-result is known in every case. The usual radical operation was performed consisting of removal of the breast, both pectoral muscles, and the contents of the axilla. A large amount of subcutaneous tissue was removed from the midsternal line to the border of the scapula. Sufficient skin was preserved to allow for primary closure of the wound in most instances, for, as the disease progresses along the deeper lymphatics and not in the skin proper, it is felt that preserving sufficient skin for primary closure is a safe procedure. This has been borne out by the fact that in the 104 cases in which the site of recurrence is known or who are living without disease, there were 6 local recurrences, or 6 per cent.

All patients were carefully studied for evidence of remote metastasis before operation and x-ray films were taken of the lungs and bones to rule out unexpected remote disease. Radical operation was performed only on those patients in whom disease was clinically limited to the breast or breast and axilla. In 5 cases, however, considering the size and extent of the disease, the operation might be considered as palliative.

That estimation of the extent of the disease is subject to considerable error is shown by the fact that 15 patients died within 1 year of remote metastases, the presence of which could not be demonstrated before operation, but without local recurrence. Axillary nodes were involved in all but 1 of these patients and in 3, although the disease was apparently local, it was advanced. Otherwise there was nothing to distinguish this group from certain other cases in which a cure was obtained.

Appraisal of axillary involvement is also subject to considerable error. In this group 84 patients presented axillary nodes clinically, in 72 of which cancer was proved to be present by pathological examination, while in 12 the nodes were inflammatory: an error of 14 per cent. On the other hand in the 63 cases in which no axillary nodes were palpable, they were found diseased in 30, representing a 48 per cent error in the clinical appraisal of the extent of the disease. It is felt that the situation of the involved axillary nodes and the number have a distinct bearing on the prognosis, but, unfortunately, these facts could not be determined from the pathological reports.

There were 4 operative deaths: an operative mortality of 2.7 per cent. Three patients died of pulmonary embolus on the 5th, 7th and 21st days, respectively, and 1 (colored) of unknown cause on the way to the ward after operation.

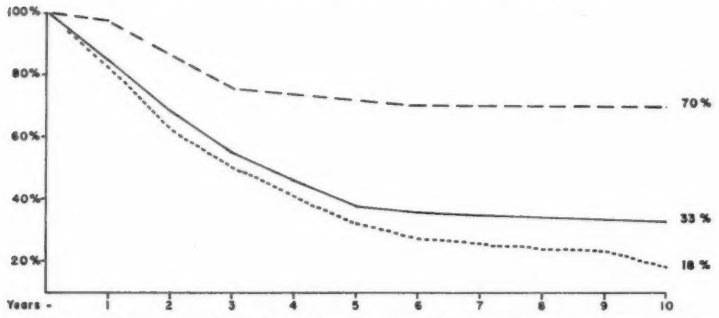

Chart 1. Ten year end-results in cancer of breast.——Total, 134 cases, 33 per cent cures; ---------, axilla involved, 95 cases, 18 per cent cures; — — — —, axilla not involved, 39 cases, 70 per cent cures. (Patients living with disease at end of 10 years considered dead.)

The results of operation on a 5 and 10 year basis are shown in Table I. Operative deaths are considered as failures, while patients dying of other causes without evidence of recurrence are excluded as inconclusive.

As will be noted in Table I, 10 patients living at the end of 5 years died later of recurrence, in 9 of whom the nodes were involved. In other words, 19 per cent of the patients living at the end of 5 years will develop late recurrence, or 7 per cent of all patients operated upon, considering the patients dying of other causes without disease as inconclusive. In studying the cases further only 1 patient in whom the axillary nodes were negative for cancer died after the 5th year and this patient showed evidence of metastases in the lung and other breast 3 years after operation; thus no patient with negative nodes developed recurrence after 5 years. In the 9 patients in whom the axillary nodes showed involvement and who developed late recurrence, all were apparently free of disease at the end of 5 years. In this group there were 30 per cent 5 year cures and 18 per cent 10 year cures. Five lived for 10 years or more after operation and with known recurrence for 4 years.

The 5 year results are approximately the same in the groups previously studied. The number of cases is small and the percentage would be influenced by the manner in which the patients dying without disease between 5 and 10 years are reckoned.

Further analysis of the cases of late recurrence is not illuminating. The average and median age of the group was 53; the average and median duration of the tumor at the time of operation was 5 months. As to the histiological index of malignancy, 7 were classed as of median and 2 of high. The chief sites of recurrence are known in 7 of these 9 cases. The bones were involved 5 times, the supraclavicular nodes 2 times, and the lungs 3 times. There was 1 case only of local recurrence which appeared at the end of the fifth year. Patients living with disease at the end of the tenth year, 4 in number, are charted as having died in that year (Chart 1).

In 75 per cent of those dying of disease, recurrence and death took place within 3 years of the date of operation.

Site of recurrence. The site of recurrence is known in 60 of the 88 cases dying of disease, many obviously having multiple metastases. The bones and lungs were the most common sites of metastases, being involved in 29 and 26 instances, respectively. The cervical nodes were the next most common seat, 17 patients having recurrence in that region. Cancer of the other breast, which has been considered as being metastatic, was noted in 5 instances. Six per cent only developed local recurrence.

Preoperative irradiation. Twenty-six patients in whom the nodes were involved received pre-

TABLE I.—RESULTS OF OPERATION

	Five Years	Ten Years
Living	61 (40%)	44 (33%)
Dead		
of disease	76	86
operative	4	4
Inconclusive		
dead of other cause without recurrence	6	13

TABLE II.

	Axilla not involved		Axilla involved	
	5 year	10 year	5 year	10 year
Living	31 (73%)	27 (70%)	30 (30%)	17 (18%)
Dead	11	12	69	78
	42 cases	39 cases	99 cases	95 cases
Inconclusive	3	6	3	7

operative x-ray treatment. Five of these patients are living (19 per cent) while 21 are dead, 20 of whom died within 5 years while 1 lived 11 years. It is only fair to state that the amount of irradiation given to these patients, as judged by today's standards, was totally insufficient seriously to affect tumor cells.

SUMMARY

It would appear from this analysis that in cases of cancer of the breast in which the axillary nodes are not diseased, patients living without clinical evidence of cancer at the end of 5 years may be considered as permanent cures (70 per cent 10 year cures). But, in patients with positive nodes at the time of operation, 19 per cent living at the end of 5 years will eventually die of late recurrence, or 7 per cent of the cases operated upon. These figures might be changed for better or worse if it were not necessary to exclude as inconclusive cases the 13 patients dying of some other cause before the expiration of 10 years following operation. The results of this study are shown graphically in Chart 1.

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EDITORIALS

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THE PRESENT STATUS OF THE CANCER PROBLEM

So much has been written on the subject of cancer in recent years that it is not an easy matter to sift out the facts from the near-facts and obtain a true picture of progress and actual accomplishment.

As never before, the medical profession is increasingly aware that cancer is one of the two greatest and most pressing problems of modern medicine. Heart disease and cancer are our two chief killers. Wilson, of the Harvard School of Public Health, recently found, for the first time in the annals of American medicine, that more women during the twenty-year span, from thirty-five to fifty-four years, die of cancer than of any other single disease.

It is obvious that the cancer patient must come to the doctor early in the course of his disease if a cure is to be effected; but few realize, however, that over half of the patients suffering from cancer will not be cured, no matter if they go to their physician at the very first symptom manifestation. Hodgkin's disease, leucemia, cancer of the pancreas and of the esophagus, as well as sarcomas of bone, offer small chance of cure. And the first symptom of gastric, ovarian, testicular, lung, antrum, and even breast cancer, is not infrequently that of metastasis or direct invasion into irremovable vital structures. On the other hand, so much is to be gained from an intensive campaign of cancer control for the other half that does have an opportunity for cure if diagnosis is made early and treatment given, that in all probability "cancer control," which teaches the symptoms and signs of cancer to the laity, is our most effective single step in the cure of those who have an opportunity for cure.

The annual physical examination not infrequently reveals cases of both early and late cancer; however, it has proved to be a disappointment as far as effectiveness goes in finding early cancer.

As a whole, the general public, particularly during the past few years, has learned much about the disease. Widespread fear persists, but it is encouraging to note that the last Gallup poll on the subject revealed that 52 per cent of the population now believe that early cancer is curable. The previous Gallup poll had shown that 48 per cent of the population believed early cancer to be curable. There are signs which make us realize that in certain quarters progress is unquestionably being made. It is only recently that McCarthy, of the Mayo Clinic, reported that in their cases of operable breast cancer, it is necessary to perform a biopsy in three times the number of cases it was fifteen years before. This demonstrates that the mammary cancers of today

are smaller, and therefore more difficult of diagnosis.

Although delay from the time of the first symptom until the patient's entry into the hospital for treatment is still appalling, a recent study made at the Memorial Hospital in New York, revealed that twenty years ago, in these same operable breast cases, the average delay was eleven months, seven days; while in 1940 the average delay was four months, seven days—a reduction of 62 per cent in valuable time lost. There are several evidences which demonstrate that the education of the public is catching hold. It is interesting to note two entirely new, and what are proving to be effective, methods of teaching the subject of cancer to the lay public. Five years ago the American Society for the Control of Cancer organized the Women's Field Army Against Cancer. Its chief aim was to enroll women in a campaign, pledging themselves to become informed on the simple signs of cancer, and to take the responsibility for the teaching of this information to the members of their immediate families. This campaign met with signal success. Today there are 225,000 women enrolled in this educational effort; and it is very largely through their influence that much new legislation has been effected, looking to improved care of the indigent cancer patient in several states. It is also the result of their influence that President Roosevelt declared the month of April to be "Cancer Control Month."

The other new experiment is taking place in Westchester County, New York, where a small textbook of seventy-five pages, "Youth Looks at Cancer," is being taught in the biology department of all high schools, and the problem of abnormal growth is being rationally and normally approached.

The program of the Cancer Committee of the American College of Surgeons has been broad and aggressive. The College gives its stamp of approval to the idea that cancer is such a comprehensive disease that special training in diagnosis, pathology, and treatment is desirable. The College has been effective in establishing 370 cancer clinics in the United States and Canada, representing 20 per cent of the total approved hospitals of 100 beds or over. It is a policy that at the annual Clinical Congress, the subject of cancer shall be presented to the Fellows by a series of papers, by symposia, and by the giving of cancer clinics. Aside from this, the College maintains a registry for cured cancer cases which is available for study. There are now over 36,000 such cases of cured cancer registered. Now that many of the cancer clinics have been established for a period of five years, it is anticipated that the registration of cured cases will proceed at a rapid rate and that the College will soon have 100,000 cases of cured cancer—a monument to the effectiveness of good surgery and sound irradiation.

From the professional point of view, another bright spot is that a comparison of medical school curricula of 1940 with those of 1920 reveals a real increase in the hours allocated to the medical student on the subject of cancer. The medical schools are now beginning to make greater use of their material of the cancer clinics for teaching purposes.

On the whole, sufficient new experience has now accumulated in the fields of surgical and irradiation therapy to make a more exact evaluation of them possible. We now hear less of those extravagant claims which a new and impressive agent inevitably brings out. From experience we now know that there is no place for inadequate or poor surgery in this field. In spite of voluminous literature to the contrary, largely produced by discouraged surgeons and overzealous radiologists, we now find there is no place for incomplete surgery

being done with the idea that "cure" of the remaining disease will be effected by irradiation. Radiation is an exact and effective therapy which should be carried out by those familiar with its accomplishments as well as its limitations. In certain pathological states irradiation is more effective than surgery; and the reverse also holds true. And there are situations in which a combination of good surgery and expert irradiation offers most.

It seems that at present lead therapy as well as "freezing," the latest widely heralded "cure," have been abandoned. The effects on cancerous tissue of the radioactive isotopes, phosphorus, and strontium, are undergoing critical study. Cancer research laboratories are working ceaselessly on these and other leads. It takes much time and experiment before a "cure" can be accepted. We must hold fast to those two agents which have proved to be most effective, namely, "cancer control" and the expert use of surgery, radium, and x-rays.

FRANK E. ADAIR.

OBSTRUCTIVE JAUNDICE

THE treatment of obstructive jaundice has been shown recently to demand not only especial attention to the preoperative and postoperative care but in addition great care in the selection of the actual operative technique for the case involved. In 1878 J. Martin Sims performed the first premeditated operation on the gall bladder in a jaundiced patient. The patient died, apparently from a biliary fistula due to failure to remove the stone from the common duct. The second jaundiced patient was operated upon by W. W. Keen of Philadelphia, and this patient died in 36 hours from hemorrhage, exhaustion, and shock.

The mortality of operations upon jaundiced patients remained high until the twentieth century at which period the emphasis in surgical study and investigation was placed upon anatomy and pathology. The chief factor in the mortality from operations upon this type of patient was not the result of an insufficient knowledge of pathological anatomy, but rather to a lack of knowledge of the fundamental pathological changes in the physiology occurring in the jaundiced state. The work of Rous and McMaster on the bile and extrahepatic bile ducts, and of Rosenfeld, Wells, and Ballman and Mann on the liver, were among the first important investigations of this character. With the aid of the information obtained by such studies, certain principles have been formulated regarding the preoperative and postoperative treatment of jaundiced patients with a resulting markedly lowered surgical mortality. That the physiology of this condition is not yet completely understood need hardly be mentioned. Indeed, it is but recently that the most important contribution in years has come to the surgeon's aid in the treatment of jaundice—namely, vitamin K and bile salts.

Obstructive jaundice to be amenable to surgery must be within reach of the surgeon, either in the common hepatic or the common duct itself. Many of the problems involved in the treatment of such an obstruction are the same irrespective of the type of obstruction. There occurs an increase in the ductal pressure which may be greatly delayed when the gall bladder is normal as in cases of carcinoma of the pancreas. As the pressure approaches 330 millimeters of bile, the hepatic secretion of normal bile stops. The bile pigment no longer is secreted into the common duct. The mucus secretion of the bile dilutes the bile already present and the pigment is absorbed. The ducts are thus filled with the "white bile" familiar to us all. It is common knowledge that the presence of "white bile" in the common duct is a "bad sign" and definitely in-

creases the surgical risk. This is true only because it is evidence of liver injury. The preoperative evaluation of the degree of liver injury is difficult or impossible. A rough idea may be gained by the indirect van den Bergh reaction (degree of jaundice) and the duration of the jaundice. Of the various liver function tests, the hippuric acid test of Quick is probably the best method available at present for determining liver function. In the jaundiced patient, however, the liver damage is evident, but the degree may be questionable. In any event every effort must be directed toward the improvement of the liver function before operation.

For a number of years attention has been centered upon the carbohydrate metabolism in the liver when associated with jaundice. It has been shown that the glycogen stores in this organ are greatly decreased. Therefore, it has become the widespread practice to force the ingestion of carbohydrates in the preparation of these patients for operation. This has, undoubtedly, been very helpful. However, when biopsies were taken of the liver and a number of patients prepared in this manner, it was found that the liver contained a large amount of fat. It has also been shown in experimental animals that the liver glycogen may be increased only by a diligence in the forcing of carbohydrates far beyond that previously taken.

As a result of a series of experiments carried on in the Harrison Research Department of the University of Pennsylvania under the direction of Dr. Ravdin, we have come to believe that the amount of glycogen in the liver is not as important a factor as the amount of fat in the liver at the time of operation. It has been conclusively shown that the degree of liver injury following volatile anesthetics is dependent upon the amount of fat in the liver and not on the glycogen content. The problem in the preoperative preparation of the jaundiced patient, therefore, is to remove the fat from the liver as rapidly as possible. Our experimental evidence has demonstrated that this is most effectively done on a diet high both in protein and carbohydrates with no fat. It has been our practice to give a diet in which 14 per cent of the calories are supplied by protein. The rationale of this change from a pure carbohydrate diet to a protein-carbohydrate diet is well founded, for it now seems likely that a great portion of the value received from the carbohydrate regimen used in the past was its ability to spare the protein in the body.

The patients with common duct obstruction frequently have such a reduction in appetite as to constitute a major problem in their preoperative preparation. Here the feeding of vitamin B and lyophilized bile is helpful at times. In the occasional patient with severe liver injury and a poor appetite, it may even be advisable to pass a tube into the stomach or even into the jejunum and give forced feeding of partly digested protein and carbohydrates.

The most alarming complication in the jaundiced patient is hemorrhage. Before Quick began his studies on the prothrombin in these patients the surgeons were at a total loss to explain why one patient bled and another just as deeply jaundiced did not bleed. Studies of the bleeding and clotting time were of no avail. Now for the first time we apparently have a reliable method of determining the prognosis of the patient regarding the bleeding tendency.

The discovery of vitamin K by Dam and also Amquist has added a new and much needed chapter to the treatment of jaundice. It is now common practice to study the prothrombin of every patient so affected. Vitamin K in some form is fed to the patient

with ample bile salts (sodium desoxycholate). Vitamin K is a lipid and is not absorbed adequately from the intestinal tract in the absence of bile salts. The prothrombin values may be determined day to day so as to follow the improvement, which usually occurs rapidly. It can be anticipated that the prothrombin will fail to rise after such therapy only in patients with jaundice due to severe damage to the liver cell such as probably seldom occurs as the result of common duct obstruction alone. Although vitamin K is a recent addition to the surgeon's armamentarium, its value in the preoperative treatment of these patients is rapidly being established. Certainly the surgeon is no longer justified in operating upon a deeply jaundiced patient without a knowledge of the prothrombin value and the use of vitamin K if it is low.

Before the use of vitamine K the incidence of hemorrhage following operation remained about the same year in and year out. The mortality following these hemorrhages was materially reduced by repeated blood transfusions. Doubtless we shall find patients with severe liver damage who fail to respond to this type of therapy. We believe that such patients will be few. It may be possible to predict and experience may show that a failure to respond to vitamin K therapy will suggest that the jaundice is due to injury to the liver cell rather than to simple common duct obstruction, thus eliminating surgery.

The prothrombin may be increased rapidly by blood transfusions. This doubtless accounts for the benefit derived from the multiple small transfusions as used for some years in these cases. Studies by Dr. John Rhoads at the University of Pennsylvania have shown that fresh blood should be used in these transfusions, as "bank blood" loses its prothrombin rapidly. It goes without saying that if the surgeon is forced into operation upon a patient whose prothrombin does not rise following vitamin K therapy, multiple small transfusions of fresh blood, as in the past, continue to be the treatment of choice.

Volatile anesthetics which are toxic to the liver cell should be avoided in the surgery of the jaundiced patient. Nitrous oxide and the barbiturates are also bad because of the anoxemia which frequently accompanies their administration. Ethylene and cyclopropane gases which may be given with a high percentage of oxygen are probably less objectionable although accurate control studies have not been made of these agents in the experimental laboratory. Local anesthesia is undoubtedly the anesthesia of choice from the standpoint of the liver. However, it seldom affords sufficient relaxation to carry on the operation required. Its usefulness is definitely limited by the temperament and build of the patient and the temperament and skill of the surgeon. Spinal anesthesia conducted by a physician anesthetist should be considered the anesthesia of choice. It is indubitably an excellent anesthesia, its chief drawback, however, being the anoxemia that is associated with the occasional drop in blood pressure. For the same reason surgical shock is to be avoided in these cases.

The postoperative care of the jaundiced patient is a continuation of the preoperative care plus the additional attention to the wound and biliary fistula if established.

It is highly important to continue the patient's nutrition in a usable form. The most acceptable method has been a continuous venoclysis of glucose solution until the patient can retain an adequate intake by mouth. Recent investigations in the experimental animal in the laboratory suggest that the amount of glucose that is usually given by venoclysis is not great enough to give the best

results. These experiments have attested to the value of passing a tube into the jejunum before operation so that forced feeding of a high carbohydrate protein may be administered for a few days before and after operation.

The continuation of the antihemorrhage therapy is imperative. Vitamin K should be given and bile salts must be given also since bile salts do not reappear in the bile for a considerable period of time after the release of common duct obstruction. Small transfusions of fresh blood should be given every 8 hours in the most severely jaundiced cases for 2 or 3 days. Vitamins other than K are now being added.

The use of a decompression apparatus in the drainage of the biliary tract may be useful. When only a first stage operation—a cholecystostomy—is done, the pressure in the biliary tract may be reduced gradually in the same manner as in decompression of the urinary tract. This may reduce the possibility of bleeding. When the obstruction has been removed the pressure in the biliary tract will depend upon the duodenal pressure, as for example in the cholecystoduodenostomy. When a T tube has been placed in the common duct the decompression apparatus is helpful in forcing the bile into the duodenum, rather than allowing it all to escape externally.

If the patient loses a sufficient amount of bile externally there may be a profound biochemical disturbance which is not entirely understood. Unless this bile or its equivalent is given back to the patient he may develop marked listlessness and sudden attacks of a shock-like state with a low blood pressure and cold sweats. Refeeding the bile in its entirety by a slow drip through a tube in the stomach is useful. Lyophilized human bile collected from previous patients and lyophilized pig's bile have recently been used very successfully.

The length of time the T tube should be left in the common duct varies somewhat according to circumstances. In the ordinary case of common duct stone we usually remove it on or about the 14th day. The tube is clamped entirely for several days before its removal. In the case of a stricture for which a plastic operation has been done, the tube is left in place for months in an endeavor to minimize further scar contracture.

Space does not permit discussion of the surgical procedures incident to the correction of the various types of obstruction which may be producing the jaundice.

ELDRIDGE L. ELIASON.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

MEDICAL men of today, surgeons in particular, have long been familiar with the saga of the Mayos—father and sons. To them it has always been an inspiring and stimulating story, and they have recognized almost without exception the forceful impetus the Mayo Clinic has given to medical and surgical progress, and what a far-reaching and helpful part it has played in American life for the past 50 years. Even those who know the story best will be grateful for the opportunity to read the complete and well authenticated account of Miss Clapesattle.[1]

The most forceful appeal of this volume, to the reviewer, is in the stimulus it affords and the example it upholds for the medical student of today. Cushing's *Osler*, McCallam's *Halstead*, Watson's *Life of Sir Robert Jones*, *The Horse and Buggy Doctor*, Flexners' *William Henry Welch*, and now *The Doctors Mayo* are all comparatively recent volumes. They should be in the library of every medical school and hospital. The man with the divine spark burning brightly may not need to know what others before him have achieved, but most of us are not provided with self starters, and a few turns of the crank at the right time can sometimes accomplish wonders.

As to the story itself, it is well told and with not too much flourish and fancy writing. The opening chapters are a little tedious and the account of historic facts, diligently sought out and verified, are too often elaborated with descriptive passages and generalizations that detract from the directness of the story. With the beginning of the Rochester period the story comes to life, and from that moment almost every page, except for the elucidation of surgical procedures, is interesting. Gradually one character emerges as the dominating personality, that of Will Mayo; and though the picture of Dr. Charlie, the lovable and understanding surgeon, the skillful technician, the much sought after "trouble shooter" is skillfully portrayed, it is Dr. Will who finally holds the center of the stage.

"Stress the time and the opportunity," said Dr. Will to his biographer. "We were reared in medicine. . . . There were three of us. . . ." All well and good; but at the center of every effective effort in this world of ours, whether for good or evil, there is one individual who provides the divine fire that kindles and burns and, sometimes, starts a conflagration. Such an individual was Dr. Will Mayo; and in reading *The Doctors Mayo* one cannot help but conclude that the outcome would have been the same whether his lot had fallen in Rochester, in Boston, or in London. His debt to others, freely acknowledged, was great, but so is that of any other leader of men.

The most arresting incident of the volume is that briefly told on page 698, "I've just done my last operation." To take off the mantle, worn so long, voluntarily and gracefully; to pass it on to younger men, and to bid them Godspeed; and to do it without a sign of self-pity—in that act are all the elements of drama—heroism, renunciation, forgetfulness of self. Of men with the ideals and force of character of Dr. Will and Dr. Charlie the medical profession has every right to be proud.

To review in more detail a book so interesting and stimulating is needless. Every medical student and every doctor will find in it interest, humor and inspiration; and the young man in particular can recall Napoleon's words, "Every French soldier carries in his knapsack the baton of the Marshal of France."

SUMNER L. KOCH.

TOBIAS has turned out an excellent volume giving the essentials of dermatology.[2] The material is up-to-date, is authentic for the day, and is presented in a clear, if succinct, manner. The book pretends to no more than a brief treatise so that it does not contain references to pertinent literature, etymological notes, or statistical facts. The volume is sparsely illustrated, but the illustrations that are shown are well chosen and are all in black and white. The basic principles of diagnosis and treatment are adequately considered and there is included even definitions of the more rare dermatoses. The book should prove to be very useful to the student and the practitioner as all of the common cutaneous diseases are treated quite adequately although the text is brief. The one criticism that I would make is the paucity of photographs. Those that are included are excellent, but I believe the book would have a great deal more merit with a few more photographs of the commoner skin diseases. This criticism is negligible in relation to the book as a whole. It deserves a fine reception for it is one of the best of the smaller introductions.

EDWARD A. OLIVER.

THE lectures of Lawrason Brown on the history of tuberculosis were an important part of the courses in the Trudeau School of Tuberculosis. They have been perpetuated in a volume entitled *The Story of Clinical Pulmonary Tuberculosis*[3], which contains the lectures posthumously edited by Mrs.

[1] THE DOCTORS MAYO. By Helen Clapesattle. Minneapolis: The University of Minnesota Press, 1941.

[2] ESSENTIALS OF DERMATOLOGY. By Norman Tobias, M.D. Philadelphia, London, Montreal: J. B. Lippincott Co., 1941.

[3] THE STORY OF CLINICAL PULMONARY TUBERCULOSIS. By Lawrason Brown, M.D. Baltimore: The Williams & Wilkins Co., 1941.

Brown. With the exception of the chapter on x-ray by Homer L. Sampson and that on chest surgery by Edward W. Archibald, the material is essentially in the inimitable manner of Dr. Brown. The 381 pages present an intensely interesting parade of the historical background of the refinements in chest examination and the study of tuberculosis.

The delightful narrative style makes the book a pleasure to read. It is a source book of early history in which the author has gleaned the facts from a lifetime of reading. The bibliography is quite complete and representative. The volume is well indexed both by subject and author titles. This is a good practical volume and should be in the library of anyone interested in clinical tuberculosis or the history of medicine. E. L. WALSH.

IT is with great satisfaction that the reviewer studies a new text on endocrinology. Grollman's *Essentials of Endocrinology*[1] is a moderate sized single volume compilation written for the medical student or anyone wishing to get a general scientific grasp of the endocrine field. Other works on this subject have suffered from specialization upon one gland or, on the contrary, because the author has presented a diffuse clinical picture with excessive therapeutic claims The present volume is a complete scientific epitome of present endocrine knowledge. There are some passages and some conditions in the work that can be criticized; there are occasions when contradictions seem to be presented; for instance, in the discussion of "dwarfism due to pituitary insufficiency" it is emphasized that the appearance is one of "precocious senility," but in the illustration of a typical case of pituitary dwarfism the "juvenile appearance" is pointed out. On the whole, the discussion is brief and precise; description of syndromes is necessarily abbreviated; physiology and pathology are accurately stated and therapy is presented in a conservative manner but with encouragement when warranted. PAUL STARR.

THE monograph on *Orbital Tumors*[2] by Dandy consists principally of a review of the histories of 25 patients with operable and 7 with nonoperable tumors of the orbit, all verified microscopically. These tumors included fibromas, osteomas, meningiomas, sarcomas, carcinomas, gliomas, osteomatous cysts, Schueller-Christians's disease, and inflammatory masses. Hyperostosing meningiomas were present in greatest number (9), and Schueller-Christian's disease was second in numerical prominence (5). An account of the patient's complaints and neurological signs, the operative note, and a brief histological discussion accompany the presentation of each case history.

The operative approach was in most instances a modification of that used by most neurological surgeons in their attack upon orbital tumors. Dandy uses a "concealed skin incision" to effect a transfrontal osteoplastic flap, placed somewhat laterally in the frontal region. The advantages of the transcranial approach over the Kroenlein and other external orbital approaches is pointed out, and the accessibility of the orbital contents and the possibility for complete removal of the tumor without incidental damage to orbital nerves, vessels, and muscles is attested to by the improvement in the patients and the nonrecurrence of the tumors after the patients had been followed for many years by the author.

The outstanding feature of the book is unquestionably its fine illustrations. They alone could tell the story. The artist's sketches of the tumors *in situ* as well as the operative sketches are excellent. The photographs of the patients before and after operation, of the tumor specimens both gross and microscopic, and of the x-ray pictures of the skull indicate how long, carefully, and patiently the author collected his illustrative material. Several of the case histories are made spectacular by the illustrations alone. JOHN MARTIN.

A SYMPOSIUM delivered at Vanderbilt University in April, 1941 has been published as *Infantile Paralysis*[3] by the National Foundation for Infantile Paralysis, Inc. The purpose of the meeting as set forth in the preface was to inform the medical profession and the public the "extent of advance and the limitations of the contributions of science to the solution of the manifold and intricate problems of poliomyelitis."

The book is written in sections by six contributors: "History of Poliomyelitis up to the Present Time" by Paul F. Clark, Ph.D.; "The Etiology of Poliomyelitis" by Charles Armstrong, M.D.; "Immunological and Serological Phenomena in Poliomyelitis" by Thomas M. Rivers, M.D.; "The Pathology and Pathogenesis of Poliomyelitis" by Ernest W. Goodpasture, M.D.; "The Epidemiology of Poliomyelitis" by John R. Paul, M.D.; "The Treatment and Rehabilitation of the Poliomyelitis Patient" by Frank R. Ober, M.D.

The literature is comprehensively reviewed, but the authors do not clarify the issues so that one unversed in virus diseases can obtain a clear picture. The result is the impression that nearly all claims for progress in the study of poliomyelitis have been refuted. Such, of course, is not the fact. Here and there is an island of crystallized thought, but too often the few truths about poliomyelitis are lost in the discussion. The consensus of the authors is that the research has reached a plateau; that, despite much effort, nothing new has been discovered for some time, and that we must develop new methods of investigation.

As a review intended for the general practitioner, the book does not fulfill its purpose. There is too

[1] ESSENTIALS OF ENDOCRINOLOGY. By Arthur Grollman, Ph.D., M.D. Philadelphia, London, Montreal: J. B. Lippincott Co., 1941.
[2] ORBITAL TUMORS; RESULTS FOLLOWING THE TRANSCRANIAL OPERATIVE ATTACK. By Walter E. Dandy. New York: Oskar Piest, 1941.
[3] INFANTILE PARALYSIS; A SYMPOSIUM DELIVERED AT VANDERBILT UNIVERSITY IN APRIL, 1941. New York: The National Foundation for Infantile Paralysis, Inc., 1941.

much detail of experimental work. The sections are repetitious and overlap considerably. No contributor seems completely aware of the productions of his fellow, hence the duplications. The literature is so completely covered that the reader is confused by the number of quotations and the paucity of conclusions that may be derived.

The book leaves the reader flat. Certainly after one notes the names of the contributors, he is disappointed in the content of their lectures. The lack of integration between sections furthers the feeling that a clearer picture could have been presented.

A redeeming feature is the rich bibliography, valuable for one interested in the details of the experiences of the investigators of infantile paralysis. However, as a book intended to present the current status of the knowledge of this disease to the physician, health officer, and ultimately the public, the symposium falls short of the mark.

BENJAMIN BOSHES.

THE book *Abdominal Surgery of Infancy and Childhood*[1] by Dr. William E. Ladd and Dr. Robert E. Gross of Boston, recently published by W. B. Saunders of Philadelphia, is without question the outstanding work in this field, with due respect to that of Barrington Ward of England, published in 1937.

Some books on surgery are of value not because they express the opinions of the author, but because they cover an exhaustive review of the literature and, therefore, include a variety of leading opinions. Such books, unfortunately, often confuse the reader and leave him quite in doubt as to the best methods of procedure. Other books are of value because they convey almost exclusively the opinions of the author himself, opinions based on a wide experience in his field over a long period of time, references to the literature being incidental. This book by Dr. Ladd and his younger associate, Dr. Gross, is an outstanding example of the latter type of work, inasmuch as it is the product of the life work of the man whom we all recognize as the leader in this country, if not in the world, in the realm of children's surgery.

Expressed in simple, clear cut language which is easy to read, accompanied by admirable photographs, excellent drawings, and clear x-ray films, the authors convey to the reader the data on their own experiences or others of their staff during the past 32 years at the Children's Hospital in Boston, each chapter covering the etiology, pathology, clinical symptoms, diagnosis, and the types of treatment they have found most useful. Invariably, the authors have concluded each of the 36 chapters by a brief summary of the end-results which have been obtained by a long period of follow-up.

I have the impression after carefully reading this book that it is of inestimable value not only to the young students of medicine and the men in general practice, but to all those who have a special interest in this field, whether he be a pediatrician or surgeon.

EDWIN M. MILLER.

THE admirable monograph *Lymphatics, Lymph, and Lymphoid Tissue*[2] by Drinker and Yoffey represents an elaborate extension of the original monograph of Drinker and Field on *The Lymphatics, Lymph, and Tissue Fluid* (1933). The new monograph contains a section dealing with lymphoid tissue and a chapter on the electrolytes of lymph, written by Dr. A. B. Hastings. This monograph is uniquely complete in its clear and succinct presentation of what is known of the significant anatomical and physiological aspects of the subject and its discussion of the clinical problems which daily arise in the mind of the physician. A large amount of data is presented and all the subject matter is critically analyzed. Facts are separated from fancy, and the error or uncertainty of a number of current notions regarding the lymphatic system is exposed. The monograph should be read by every student of physiology, bacteriology, and pathology. It is highly recommended to the surgeon and the internist; however, the general practitioner and the specialist, regardless of his degree of specialization, will also find information that will assist him in his everyday practice.

A. C. IVY.

IN the third edition of *Body Mechanics in Health and Disease*[3], the authors give greater attention to the prevention of deformities which have faulty body mechanics as their underlying cause. A new chapter on developmental deformities is added and some of the chapters, wholly rewritten, include the conception that the maintenance of physical fitness and health is important in the prevention of developmental deformities. A practical application of this conception is illustrated with case reports. The instructions for exercises have been entirely rewritten. The clarity, diction, and style with which poor body mechanics is described are commendable.

Body types and body mechanics are described. Back strains as well as alterations of the circulatory system are discussed. There are a chapter concerning cardiac conditions written by Kerr with a description of the Kerr-Lagen belt, a chapter concerning the diseases of the abdominal viscera and one about the diseases of the nervous system, a chapter discussing chronic arthritis with especial regard to postural disturbance.

Cases of diseases of the nervous system including multiple sclerosis and muscular dystrophies are cited; they show the treatment for improved posture and the symptoms relieved. The value of improved

[1]ABDOMINAL SURGERY OF INFANCY AND CHILDHOOD. By William E. Ladd, M.D., F.A.C.S., and Robert E. Gross, M.D. Philadelphia and London: W. B. Saunders Co., 1941.

[2]LYMPHATICS, LYMPH, AND LYMPHOID TISSUE: THEIR PHYSIOLOGICAL AND CLINICAL SIGNIFICANCE. By Cecil Kent Drinker, M.D., D.Sc., and Joseph Mendel Yoffey, M.Sc., M.D., F.R.C.S.(Eng.). Cambridge, Massachusetts: Harvard University Press, 1941.

[3]BODY MECHANICS IN HEALTH AND DISEASE. By Joel E. Goldthwait, M.D., F.A.C.S., LL.D., Lloyd T. Brown, M.D., F.A.C.S., Loring T. Swaim, M.D., and John G. Kuhns, M.D., F.A.C.S. With chapter on the Heart and Circulation as Related to Body Mechanics. By William J. Kerr, M.D., F.A.C.P. 3d ed. Philadelphia, London, and Montreal: J. B. Lippincott Co., 1941.

body mechanics in the treatment of chronic arthritis as well as in prophylaxis, particularly in the hypertrophic type, is emphasized. The treatment requires understanding of these chronic conditions; it requires patience and time, but it offers help to individuals who are otherwise neglected and permitted to suffer, with the consequent advancement of the illness and increased loss of function.

Nothing is said of the cause of poor posture. Poor posture is apparently assumed to be primary. The results obtained by the authors are in accord with the conception that poor posture is secondary to the functional decompensation; that the altered posture itself then is a factor in decreasing functional capacity. Correction of the deformity will improve functional capacity, and removal of strain as well as increase of strength will re-establish normal function with relief of symptoms. The value of vitamins and minerals is granted in certain cases, as well as the diet to diminish excess weight and thus decrease the load. The importance of good foot statics for body mechanics is stressed, but the authors advise the use of supports as a means of treatment instead of correction of the altered position and re-establishment by means of normal functional exercise, namely, correct gait.

The application of the concepts brought forth is practical as is demonstrated by the case reports which show what can be accomplished by the use of treatment for impaired body posture in chronic cases. The importance of good body mechanics in the maintenance of physical fitness and health is emphasized.

This is a basic book for the orthopedic surgeon and is recommended to physical therapists, physical education teachers, public health physicians and nurses, and to internists, especially those interested in chronic diseases.

EMIL D. W. HAUSER.

THE development and experiences in England of the Health of Munition Workers Committee from its inception in 1915 through to the establishment of the Industrial Health Research Board is traced in Vernon's *The Health and Efficiency of Munition Workers*.[1] It depicts a prolonged, intensive study of the complexities of the human element in industry. As such, experiences in hours of work, rest periods, night shifts, sickness and absenteeism, accidents, fatigue, ventilation, heating, lighting, welfare problems, and their relationship to employe efficiency are related. These problems are considered in the light of data accumulated in World War I, peacetime in private industry, and the experiences of today.

The book is of great interest to those of industrial management interested in industrial relations, employe welfare and safety education. As a reference work in a library of industrial medicine it is of value; to one, however, just casually interested in industrial practice, it is only of limited interest.

E. L. WALSH.

THE contents of Bancroft's *Operative Surgery*[2] deal with the surgical treatment of abdominal diseases and, with the exception of the section on spleen, do not deal with etiology, pathology, or diagnosis. Comprising 20 sections by as many widely known contributors, the work represents a distinctive departure from previous similar works, because of the uniformly splendid character of each section and because a complete treatise on the operative surgery of the abdomen is contained within one volume.

Section I concerns anesthesia, preanesthesia, drugs, inhalation, rectal, spinal and regional anesthesia. Section II concerns preoperative and postoperative treatment and is an extraordinarily fine and complete exposition of fluid balance, chemistry, shock, vitamin therapy in abdominal surgery, and hypoproteinemia. Section III covers blood transfusion. Section IV about the general principles of surgical technique, skin preparation, sutures, hemostasis, etc., attracted the attention of the reviewer because it is fascinating reading. There follow sections on the mouth, including neck dissections; a section on abdominal incisions, in which there is an interesting exposition of and argument for the transverse as opposed to the longitudinal incision. The remaining sections are exclusively about abdominal conditions and in the following order include peritonitis, gastroscopy, stomach and duodenum, jejunal ulcer, small bowel, appendicitis, colon and rectum, anus, bile tracts, liver, pancreas, spleen, and diet in postoperative abdominal conditions.

Avoiding vague generalities of praise, certain specific comments should be made. Practically all operative procedures suggested throughout all sections conform to the generally accepted ideas thereon. The chapters relative to peritonitis, stomach, duodenum, appendicitis, small bowel obstruction, colon, bile tracts, and spleen are worthy of special mention in this respect. The once common practice in such volumes of including much obsolete material for completeness, often to the confusion of the younger surgeon, is lacking. The illustrations, for the most part line drawings, are excellent. The subject matter is presented in a most interesting fashion. The book represents a valuable contribution as a compact reference work on abdominal surgery.

J. R. BUCHBINDER.

IN a well written monograph[3] of 257 pages Spink presents in a clear, concise manner the use of the sulfonamides in the practice of medicine and surgery.

[1] THE HEALTH AND EFFICIENCY OF MUNITION WORKERS. By H. M. Vernon, M.A., M.D. London: Humphrey Milford (Oxford University Press), 1940.

[2] OPERATIVE SURGERY INCLUDING ANESTHESIA, PRE- AND POST-OPERATIVE TREATMENT, PRINCIPLES OF SURGICAL TECHNIQUE, BLOOD TRANSFUSION AND ABDOMINAL SURGERY. Edited by Frederick W. Bancroft, A.B., M.D., F.A.C.S. New York and London: D. Appleton-Century Co., Inc., 1941.

[3] SULFANILAMIDE AND RELATED COMPOUNDS IN GENERAL PRACTICE. By Wesley W. Spink, M.D. Chicago: The Year Book Publishers, Inc., 1941.

All of the newer drugs are discussed including the use of sulfaguanidine and sulfadiazine, although the chapters devoted to these drugs are of necessity short as there is at present a dearth of clinical experience with them.

Material for this text was drawn from the author's personal observation of the treatment of over 1,000 cases at the University of Minnesota Hospital. In addition, material from the contents of over 400 carefully chosen articles is included.

Chapters on general principles of sulfonamide therapy and the use of the sulfonamides in surgery are particularly pertinent and instructive. In addition to chapters which describe the use of each of the drugs individually, there are sections which are devoted to the treatment of such specific diseases as pneumonia, meningitis, and staphylococcus septicemia.

The busy clinician who has been unable to keep abreast with the voluminous literature of the past 5 years on the subject of sulfanilamide and its related compounds will find this easily readable volume a rather complete summary of the subject brought up to date. M. H. BARKER.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

TRANSACTIONS OF THE SIXTY-SECOND MEETING OF THE AMERICAN SURGICAL ASSOCIATION HELD AT THE GREENBRIER, WHITE SULPHUR SPRINGS, WEST VIRGINIA, APRIL 28, 29 AND 30, 1941. Edited by Walter Estell Lee, M.D. Vol. 59. Philadelphia: J. B. Lippincott Co., 1941.

THE BLOOD BANK AND THE TECHNIQUE AND THERAPEUTICS OF TRANSFUSIONS. By Robert A. Kilduffe, A.B., A.M., M.D., F.A.S.C.P., and Michael DeBakey, B.S., M.D., M.S., F.A.C.S. St. Louis, Missouri: The C. V. Mosby Co., 1942.

NEUROANATOMY. By Fred A. Mettler, A.M., M.D., Ph.D. St. Louis, Missouri: The C. V. Mosby Co., 1942.

SYMPTOM DIAGNOSIS; REGIONAL AND GENERAL. By Wallace Mason Yater, A.B., M.D., M.S. (in Med.), F.A.C.P. 4th ed. New York and London: D. Appleton-Century Co., Inc., 1942.

PSYCHOSURGERY; INTELLIGENCE, EMOTION AND SOCIAL BEHAVIOR FOLLOWING PREFRONTAL LOBOTOMY FOR MENTAL DISORDERS. By Walter Freeman, M.D., Ph.D., F.A.C.P., and James W. Watts, B.S., M.D., F.A.C.S. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1942.

CLINICAL ROENTGENOLOGY OF PREGNANCY. By William Snow, M.D. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1942.

A TEXT-BOOK OF NEURO-ANATOMY. By Albert Kuntz, Ph.D., M.D. 3d ed. Philadelphia: Lea & Febiger, 1942.

SKIN GRAFTING; FROM A PERSONAL AND EXPERIMENTAL VIEWPOINT. By Earl Calvin Padgett, M.D., F.A.C.S. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas, 1942.

A HAND-BOOK OF OCULAR THERAPEUTICS. By Sanford R. Gifford, M.A., M.D., F.A.C.S. 3d ed. Philadelphia: Lea & Febiger, 1942.

LESIONES TRAUMÁTICAS DE LOS MENISCOS, LIGAMENTOS CRUZADOS Y LIGAMENTOS LATERALES DE LA RODILLA By Dr. Jose Valls. Buenos Aires: El Ateneo, 1941.

BIBLIOTECA MEDICA DE AUTORES CUBANOS. Edited by Dr. Vicente Banet Pina and Dr. Tomás R. Yanes. Havana, Cuba: Ucar, García y Cía., 1941.

ROENTGEN TREATMENT OF INFECTIONS. By James F. Kelly, M.D., F.A.C.R., and D. Arnold Dowell, M.D. Chicago, Ill.: The Year Book Publishers, Inc., 1942.